

Chem-Solv, Inc. Site
Cheswold, Kent County, Delaware

Remedial Investigation Report

Volume I

May 1991



Engineers, Planners, Scientists
and Laboratory Services

REPORT

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REMEDIAL INVESTIGATION REPORT

FOR

CHEM-SOLV, INC. SITE
CHESWOLD, KENT COUNTY, DELAWARE

SUBMITTED TO

DELAWARE DEPARTMENT OF NATURAL RESOURCES
AND ENVIRONMENTAL CONTROL

AND

UNITED STATES ENVIRONMENTAL PROTECTION AGENCY REGION III

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1.0 INTRODUCTION

1.1 SITE BACKGROUND

1.1.1 Site Description

The Chem-Solv, Inc. (Chem-Solv) site is located in Cheswold, Kent County, Delaware, approximately 3 miles north of Dover on the west side of U.S. Route 13 (DuPont Highway) just south of Delaware Route 42 (Figure 1-1). The Chem-Solv facility occupied the southern third of a 1.5-acre property and consisted of a one-story concrete block building, a distillation process building, and a concrete pad (Figure 1-2). A concrete-paved skateboard park was formerly located adjacent to the office building, but was partially dismantled in 1988. A two-story wood frame apartment building, a storage barn, and a wood shed occupy the northern two thirds of the property. In the past, a mobile home was located in the northwestern corner of the property.

Surrounding land use is agricultural, residential, and commercial. Strip development, consisting of commercial establishments and private residences, is found on both sides of Route 13 in the vicinity of the site. A truck stop/gasoline station previously operated immediately north of the property, adjacent to Route 13.

The Chem-Solv site is located in an area zoned for agricultural, light commercial, and residential land use.

1.1.2 Site History

The Chem-Solv facility was in operation from 1982 to 1984. At the facility, spent industrial solvents were distilled and purified. The recovered product was then returned to the original generator for reuse. The residues generated during the distillation process, referred to as "still bottoms," were collected in 55-gallon drums. These drums were stored on the concrete pad, awaiting disposal as hazardous waste. Chem-Solv was, therefore, classified as a hazardous waste generator, transporter, and storage facility that had Resource Conservation and Recovery Act (RCRA) interim status.

On September 7, 1984, an explosion and fire occurred at the facility. The State of Delaware Department of Natural Resources and Environmental Control (DNREC) was notified of the incident and immediately initiated a site investigation to determine the nature and extent of potential soil and groundwater contamination. DNREC generated a memorandum dated September 18, 1984, outlining initial investigatory activities (Appendix A-1). The memo stated that a firefighter at the fire scene had "... observed a chemical-like material running off the concrete pad

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towards the ground." Subsequent visual inspections by DNREC personnel indicated contaminated soil adjacent to the location of the fire. Vapor monitoring at the site and chemical analysis of the soil conducted by DNREC detected some volatile organic compound (VOC) contamination of the soil.

During more detailed analysis of the waste and material handling practices at Chem-Solv, DNREC concluded that the facility had other violations of Delaware's Regulations Governing Hazardous Waste. DNREC, consequently, issued a Cessation of Operation Order (Order) to Chem-Solv dated September 21, 1984 (Appendix A-2). The Order outlined DNREC's belief that spillage of hazardous wastes onto the ground had occurred during the fire on September 7, 1984, and before the incident. DNREC ordered Chem-Solv to halt all hazardous waste handling operations with the exception of those associated with cleanup of the site. In addition, the Order required Chem-Solv to remove contaminated soil from the site and to initiate a groundwater monitoring program. DNREC initiated a soil and groundwater investigation after the owners of Chem-Solv failed to fully comply with the Order. The subsequent sections summarize the investigation undertaken by DNREC to characterize the extent and nature of soil and groundwater contamination associated with the Chem-Solv facility. Included with this discussion is a description of actions undertaken by DNREC to remediate contaminated soil and groundwater at the site.

1.2 PREVIOUS INVESTIGATIONS

1.2.1 Soils Investigation

As stated in the memo referenced in the previous section, DNREC conducted a limited soils investigation immediately after the September 7, 1984, fire and explosion at the Chem-Solv facility. Subsequently, the owners of Chem-Solv excavated approximately 10 cubic yards (cy) of contaminated soil and placed this soil into 30 55-gallon drums. Although the DNREC soil investigation consisted primarily of vapor monitoring using a portable photoionization device, one soil sample was apparently obtained from a depth of 7 feet below ground surface. This sample was transported to a laboratory for VOC analysis, but the results of this analysis are unknown. DNREC concluded that the VOC contamination consisted primarily of trichloroethene (TCE); 1,1,1-trichloroethane (1,1,1-TCA); 1,2-dichloroethane (1,2-DCA); 1-chloroethene; ethylbenzene; and toluene. Table 1-1 summarizes all Pre-RI soil investigation and cleanup activities.

During April 1985, a large portion of the drum storage pad was removed and 1,300 cy of contaminated soil were excavated by DNREC. The soil was removed to the depth of the local water table and was staged onsite for later remediation/disposal. Later that month, DNREC contracted with SMC Martin Inc. (SMC Martin), an environmental consultant, to develop remedial alternatives for onsite treatment of the excavated soil.

SMC Martin conducted two initial rounds of soil sampling on May 1, 1985, and May 10, 1985. The sampling scheme was designed to determine:

1. Whether any contaminated soil remained in the sidewalls or floor of the excavation
2. The range of concentrations of contaminants in the soil stockpile for the evaluation of feasible remedial alternatives
3. Whether any compounds other than VOCs had contaminated the soils

A total of 15 samples were collected during this sampling effort. These samples included:

- Three from the floor of the pit
- Five from the stockpiled soil
- One from the drainage way

The results of these sampling events are discussed in Section 4.2.1. Based on results from the May 1985 sampling, SMC Martin concluded that soil shredding/aeration was the appropriate alternative for remediation of the soil and issued a report, entitled Evaluation of Remedial Alternatives for Soil and Groundwater Cleanup at the Chem-Solv Solvent Recovery Facility, Cheswold, Delaware, on May 18, 1985.

On August 16, 1985, an additional 37 soil samples were collected to characterize baseline concentrations of VOCs in the soil and determine whether or not the soil contained compounds, untreatable by soil shredding/aeration.

Thirteen of these samples were taken from the in-place soil surrounding the soil stockpile. The other 24 samples were collected directly from the stockpile. The results of this round of sampling are also contained in Section 4.2.1.

The soil shredding process began on September 9, 1985, and continued until November 7, 1985. The stockpiled soils were repeatedly passed through the soil shredder equipment. Samples of the soil were taken before and after shredding and were analyzed for VOC concentration, moisture content, grain size, and pH. When analytical results indicated "acceptable levels" of VOCs in the soil after shredding, the soil was placed into the excavated pit and compacted. Otherwise, the soil was returned to the shredder for another pass. Confirmatory soil sampling was completed on November 11, 1985.

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SMC Martin published the findings of the soil shredding operation in the report entitled Removal of Volatile Organic Contaminants from Soils at the Chem-Solv Solvent Recovery Facility, Cheswold, Delaware, on May 20, 1986. The report concluded that the soil shredding process employed at the site had been successful in removing VOC contamination from granular soils.

1.2.2 Hydrogeologic Investigation

DNREC also conducted an extensive investigation into groundwater contamination associated with the Chem-Solv facility. Between September 1984 and June 1986, 43 monitoring and 7 recovery wells were installed either on or around the site. Samples of groundwater from these and domestic wells in the vicinity of Chem-Solv were collected and analyzed for organic priority pollutants, primarily VOCs, beginning in October 1984 and continuing to the present. A discussion of all historical groundwater monitoring data is contained in Section 4.3.1.

Information gathered during this investigation allowed DNREC to assess the general hydrogeologic conditions underlying the site and to delineate the plume of VOC-contaminated groundwater. An attempt was made to capture the plume by pumping and treating the contaminated groundwater by air stripping. Groundwater reclamation was conducted from December 1985 to November 1988.

Table 1-2 contains a summary of the DNREC groundwater investigation. Information contained in the table was obtained from several sources. For the most part, the Sample Data Summary Target Compound sheets provided by DNREC (Appendix B) were used to compile a summary of groundwater sampling events. These DNREC data sheets were compared with the Water Quality Data Sheets contained as Attachment J in Groundwater Decontamination, Chem-Solv Solvent Recovery Facility, Cheswold, Delaware prepared by CABA Associates, Inc. (CABA) in March 1987 (Appendix C). Well installation dates were obtained from the well drilling logs contained as Attachment A in the CABA report. For wells that had no existing logs, the installation dates were obtained from Exhibits I-9 and I-10 in the CABA report. Other sources included the May 20, 1986, SMC Martin report and the Draft Work Plan for the Chem-Solv Remedial Investigation/Feasibility Study Site - Cheswold, Kent County, Delaware issued by BCM Engineers, Inc. (BCM) in October 1989. Similar to the well installation dates, several dates of events referenced in these reports could not be confirmed by cross checking field logs, field data sheets, and so on. In these instances, the document from which the event and date were obtained is referenced at the end of the appropriate entry. Verbal communication with DNREC to confirm dates was used when possible.

In September 1984, DNREC installed five observation wells (OB-1A through OB-5A) at the site to monitor the shallow water table aquifer above an identified low-permeability horizon (Figure 1-2). Well OB-1A was installed immediately adjacent to the site of the September 1984 incident. Wells OB-2A through OB-5A were installed around the perimeter of the site. DNREC well logs are contained in Appendix D. During that same month, DNREC also sampled domestic wells in the vicinity of the Chem-Solv facility for VOCs; none were detected (SMC Martin, 1986).

DNREC initially sampled groundwater from monitoring wells OB-1A through OB-5A on October 3, 1984. Analytical results of this sampling verified VOC contamination of the shallow aquifer, with TCE being the most prevalent compound. DNREC also measured water levels twice in October 1984. These data indicated a northeasterly hydraulic gradient.

During November 1984, DNREC installed seven more monitoring wells (OB-6B, OB-7A and -B, OB-8A and -B, and OB-9A and -B). Six of the wells were installed as couplets, screened both above and below the silt layer. DNREC established a consistent well identification system. All monitoring wells screened above the silt layer were denoted with the letter "A" (e.g., OB-1A), and all monitoring wells screened below the silt in the intermediate zone of the aquifer were denoted with the letter "B" (e.g., OB-7B).

Groundwater from onsite monitoring wells and offsite domestic wells was sampled on December 5 and 6, 1984, January 29, 1985, and April 22, 1985. One of the original five wells, OB-1A, was removed in April 1985 during the excavation of 1,300 cy of contaminated soil.

In April 1985, DNREC retained SMC Martin to evaluate alternatives for groundwater and soil remediation at the site. As part of the assessment of groundwater cleanup alternatives, SMC Martin conducted a hydrogeologic investigation at the site (CABE, 1987) and issued a report entitled Evaluation of Remedial Alternatives for Soil and Groundwater Cleanup at the Chem-Solv Recovery Site, Cheswold, Delaware, on May 18, 1985.

Because of SMC Martin's findings, DNREC decided to implement a groundwater treatment system that included a groundwater pumping system and treatment of the recovered groundwater by air stripping. CABE Associates, Inc. (CABE) was retained on August 5, 1985, to design and implement the recovery and treatment system. From August to October 1985, 23 monitoring wells, 5 recovery wells, and 1 replacement domestic well were installed in and around the site. Likewise, numerous groundwater samples were collected from monitoring, recovery, or domestic wells, and two pump tests were conducted to further facilitate the design of the recovery and treatment system.

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On November 26, 1985, untreated and treated water was collected from the recovery and treatment system during a test run of the equipment. By December 11, 1985, the system was fully operational, after some minor mechanical problems earlier in December. The first round of sampling for treatment efficiency monitoring was conducted on January 2, 1986. Continued sampling occurred at least every other month in 1986. In addition, groundwater sampling from monitoring and domestic wells continued into November 1986 to assess the system's effectiveness in capturing the plume of contaminated groundwater.

On June 9 and 10, 1986, two additional recovery wells were installed. One, OB-43AR, was later added to the recovery system. The other, OB-44AR, was not used for recovery, but was used as a monitoring well, called OB-44A. Later in June, a monitoring well (OB-45B) was installed in the intermediate aquifer. This well's ability to yield water was tested on June 18, 1986, during a pump test.

A point-of-use carbon treatment system was installed at a nearby home that had a contaminated well sometime before July 14, 1986. The exact date of this installation could not be confirmed, but DNREC sampled the water both before and after treatment on that date. According to verbal communication with DNREC, the contaminated well had apparently been installed by the owner as a replacement of the property's original well. The replacement well had been installed to a depth of 50 feet on September 11, 1985, but subsequent sampling of this 50-foot well indicated unacceptable levels of VOCs. This 50-foot well was replaced with a deeper well installed to 127 feet by DNREC on May 15, 1987 (Appendix D). Subsequent sampling and analysis by DNREC did not indicate any contamination of this 127-foot well.

No groundwater or treatment system sampling occurred during the first half of 1987. From June 8 through 16, 1987, however, groundwater was again sampled from 17 monitoring and 9 domestic wells. No other groundwater sampling occurred until December 22, 1987, with the exception of untreated water from the recovery system and two domestic wells. Monitoring and domestic wells and recovery system untreated groundwater were sampled quite frequently in 1988 (January 5 and 6, March 21, April 14, May 17, June 16, July 26, and November 15).

In September 1988, the air stripping tower collapsed. After that, recovered groundwater was no longer discharged to the air stripping unit. DNREC, however, continued to discharge recovered groundwater to the Kent County sewer system until November 1988. No groundwater pumping or treatment has occurred at the site since then.

DNREC conducted quarterly monitoring of one recovery system and several domestic wells from June 1989 through May 1990. Groundwater samples were collected for volatile organic analyses on June 20, 1989, September 28, 1989, February 13, 1990, and May 1, 1990.

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1.3 REMEDIAL INVESTIGATION SUMMARY

In September 1988, an Administrative Consent Order (ACO) was signed by the United States Environmental Protection Agency (EPA), DNREC, and several of the Chem-Solv Potentially Responsible Parties (PRPs). The ACO consisted primarily of an agreement to perform a Remedial Investigation/Feasibility Study (RI/FS) in accordance with the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) as amended by the Superfund Amendments Reauthorization Act (SARA). The Chem-Solv site was initially proposed for inclusion on the National Priorities List (NPL) on January 22, 1987, and again on June 1988. The site was formally included on the NPL on August 30, 1990. DNREC is the Lead Agency for the site.

Table 1-3 contains a summary of regulatory activities occurring up to the present. The Chem-Solv PRP Committee retained BCM to carry out the requirements of the RI/FS. The Draft Remedial Investigation/Feasibility Study Work Plan for the Chem-Solv Site - Cheswold, Kent County, Delaware (Work Plan) was initially submitted to DNREC and EPA in December 1988 and revised July 1989 and October 1989. The Work Plan was approved by DNREC on December 1, 1989, and was implemented between December 4, 1989, and March 12, 1990. This report presents a discussion of the findings of the Remedial Investigation.

The draft RI Report was submitted to DNREC and EPA in July 1990. From the findings presented in the report, EPA requested that additional groundwater sampling be conducted. The Sampling Plan to Finalize the Remedial Investigation at the Chem-Solv, Inc. Site - Cheswold, Kent County, Delaware (Sampling Plan) was submitted to DNREC and EPA on February 13, 1991. DNREC approved the Sampling Plan on May 1, 1991 (Appendix A-3).

The implementation scheme of the RI outlined in the Work Plan was divided into nine separate tasks:

- Task 1: Project Planning
- Task 2: Air Investigation
- Task 3: Soils Investigation
- Task 4: Stratigraphic Investigation
- Task 5: Groundwater Investigation
- Task 6: Data Evaluation
- Task 7: Endangerment Assessment
- Task 8: Treatability Study Pilot Testing
- Task 9: Remedial Investigation Report

The subsequent nine sections summarize the activities conducted to complete each of the nine tasks. In addition, the Sampling Plan outlined three tasks for additional investigation:



- Task 1: Groundwater Sampling
- Task 2: Water Level Measurements
- Task 3: Contingency Soil and Groundwater Sampling

1.3.1 Project Planning

The purpose of this task was to prepare various documents and plans before beginning field work. Activities conducted as part of this task were:

- Initial site reconnaissance
- Preparation of specifications and selection of subcontractors (i.e., driller and surveyor)
- Arranging for site access
- Review of agency files
- Surveying of site and preparation of a topographic base map at a scale of 1 inch = 100 feet with a 2-foot contour interval
- Coordinating with DNREC before any sampling and laboratory analysis

1.3.2 Air Investigation

The air investigation was conducted onsite in October 1989, before sampling or intrusive exploration. The primary purpose of this task was to evaluate health and safety needs at the site before field activities began. Data from this investigation were also used as part of the site Endangerment Assessment (Task 7). Breathing zone monitoring was conducted using an HNu or OVA at 12 onsite locations. Two of the sampling locations were in the former spill area.

1.3.3 Soils Investigation

Seven onsite test borings (CSB-6 to CSB-12) were completed, around the edge of the former excavated area, to identify the horizontal and vertical extent of subsurface soil contamination near areas where hazardous materials had either been stored or were suspected of having been stored and to characterize soils outside the former excavated area. All seven test borings were located outside the former excavation boundary. Three soil samples were obtained from each boring. Two samples from unsaturated soils were analyzed for all Target Compound List (TCL) and Target Analyte List (TAL) fractions; one sample from saturated soils just above the silt layer was obtained from each boring and analyzed for TCL volatile organics. The borings were advanced until the silt layer (which separates the shallow and intermediate zones of the aquifer) was encountered, or 35 feet below grade, whichever came first.

The sampling intervals included the 0.5 to 2.0-foot interval, the 2-foot interval immediately above the water table, and the 2-foot interval immediately above the silt layer.

The borings were located near areas of the site where hazardous material had been either stored or was suspected of having been spilled. These areas included the former distillation building, the former excavation, and former contaminated soil stockpile areas. All borings were located outside the boundary of the former excavations. Two of the soil borings were done adjacent to the former concrete-paved area to investigate the presence/absence of contamination that may have resulted from runoff from the pad. The boring locations were surveyed for both horizontal and vertical control. More details of the soil boring program are contained in Section 4.2.2.

1.3.4 Stratigraphic Investigation

Five test borings (CSB-1 to CSB-5) were completed offsite to the bottom of the silt layer, to depths ranging from 26 to 43 feet. The locations were selected to fill in data gaps regarding the presence/absence of the silt layer onsite and hydraulically downgradient of the site. Shelby tube samples of the silt layer were obtained from two of these test borings to determine grain size and the vertical coefficient of permeability.

1.3.5 Groundwater Investigation

Seven groundwater monitoring wells were installed as part of this investigation. They were identified by "MMS" or "MWI," representing whether the well was finished within the shallow aquifer zone or the intermediate aquifer zone. Groundwater samples were obtained from these wells and from seven existing wells. Analytical data from the groundwater sampling were evaluated to determine the horizontal and vertical extent of groundwater contamination in both the shallow and the intermediate zones of the water table aquifer (see Section 4.3.1). The groundwater samples were analyzed for all TCL/TAL parameters.

Monitoring Well Installation

The locations of the shallow and intermediate-zone monitoring wells are discussed in Section 2.4.1.1. Wells completed in the shallow-zone aquifer were located in an effort to delineate the extent of shallow groundwater contamination downgradient (north-northeast) of the site.

In addition to determining the extent of shallow contamination, the distribution of contamination in the intermediate zone was assessed via the installation of three intermediate-zone monitoring wells. One of these wells was used to evaluate the quality of groundwater in the intermediate zone upgradient of the site. The remaining two intermediate-zone wells were located to determine the extent of contamination downgradient of the Chem-Solv facility.

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Well Survey

All the newly installed monitoring wells were surveyed in June 1990 to obtain horizontal coordinates and vertical elevations with reference to a known datum. Horizontal control for each of the newly installed monitoring wells was obtained to the nearest 0.1 foot. Vertical control was obtained to the nearest 0.01 foot. All surveying was performed by a Delaware-licensed professional land surveyor. The survey for the newly installed wells was tied into the same coordinate system used for the existing monitoring well locations.

Well Development

The monitoring wells were developed after installation to remove fine-grained material from around the well screen. The wells were developed approximately one hour by overpumping. Development water was discharged into 55-gallon steel drums. Head space measurements of organic vapor levels were obtained using either a flame ionization detector or a photoionization detector. According to the Work Plan, development water would be discharged directly to the ground unless elevated organic vapor measurements were recorded. No sustained organic vapor measurements above background levels were recorded during well development. Therefore, well development water was discharged directly to the ground.

Groundwater Sampling

The newly installed wells were allowed to equilibrate for a 2-week period after installation and before the collection of groundwater samples. The groundwater samples were obtained in April 1990, using the protocols described in Section 4.3.2 of the QAPJP. A sample was collected from each of the seven new monitoring wells. Each sample was analyzed for all TCL/TAL parameters. Samples were also taken from existing shallow-zone wells (26A, 33A, 39A, and 41A) and the existing upgradient shallow-zone well (22A). Analytical data generated from the newly installed shallow-zone wells and existing shallow-zone wells 26A, 33A, 39A, and 41A were used to characterize the magnitude and extent of the contaminated groundwater in the shallow-zone beneath and downgradient of the site.

Existing intermediate-zone wells 5B and 9B were also sampled in April 1990, as part of this investigation. Data generated from the three newly installed and two existing intermediate-zone wells were used to evaluate the magnitude and extent of contamination, if any, in the intermediate zone. Analytical data generated from the newly installed upgradient intermediate-zone well (MWI-1-43) in the vicinity of well 22A were used to evaluate the quality of groundwater in each zone entering the site from the hydraulically upgradient direction.

In February 1991, 14 monitoring wells were sampled in accordance with the procedures outlined in the Sampling Plan. Selected wells were analyzed for volatile organic compounds, mercury, manganese, and zinc to confirm the concentrations detected in April 1990. In addition, the wells were tested for miscellaneous groundwater quality parameters (biochemical oxygen demand, dissolved oxygen, and so forth) to evaluate groundwater reduction/oxidation conditions. Unsustained organic vapor readings of 10 to 20 units above background were recorded at one well (MH 5-7-25) while purging the well before sampling. Organic vapor measurements of 4 to 5 units were recorded for the first five gallons of water removed from the well. All subsequent readings were at background levels. Therefore, the water was not containerized for offsite disposal and was discharged directly to the ground.

Water Level Measurements

Four rounds of water level data were collected from all accessible monitoring wells to determine the hydraulic head distribution in the shallow and intermediate aquifer zones. All measurements were taken to the nearest 0.01 foot using an electric water level indicator. The top of the well casing was used as a reference point. Piezometric surface contour maps were constructed from these measurements for the intermediate and shallow zones. The horizontal hydraulic gradient, magnitude, and direction were determined for both the shallow and intermediate zones. In addition, the vertical hydraulic gradient, magnitude, and direction between the shallow and intermediate zones were determined at each well couplet location.

1.3.6 Data Evaluation

The objectives of this task were to organize the validated data as detailed in the QAPJP into a working format for analysis and to perform the necessary evaluations and interpretations to meet the overall project objectives. Task 6, therefore, had two distinct components: data reduction and data evaluation. Following are brief descriptions of each component.

1.3.6.1 Data Reduction

Data obtained from the various field investigations were condensed and organized to facilitate evaluation and presentation. Reduction of hydrogeologic data resulted in the production of various tables, figures, and drawings that describe and summarize the pertinent site features. These include:

- Figures displaying boring and monitoring well locations and elevations
- Hydrogeologic cross sections

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- Groundwater contour maps
- Boring log descriptions
- Monitoring well as-built construction diagrams

Appropriate tables, maps, and figures were produced to summarize the occurrence and distribution of contaminants at the site and adjacent environs. These are referenced in Sections 3.0 and 4.0.

1.3.6.2 Data Review

BCM reviewed the reduced form of the data obtained during the RI to evaluate whether the RI/FS project objectives were met. The results of this data evaluation are contained in Section 4.0.

1.3.7 Endangerment Assessment

The endangerment assessment (EA) was used to determine the probability and magnitude of risk, if any, to human health and the environment due to actual or probable releases of chemicals associated with the Chem-Solv site.

The EA is a formalized process consisting of four tasks: (1) hazard identification, (2) exposure assessment, (3) toxicity assessment, and (4) risk assessment.

The procedures used in this EA were consistent with the Endangerment Assessment Handbook (PRC, 1985). The risk evaluation was based on the Superfund Public Health Evaluation Manual (SPHEM) (EPA, 1988).

1.3.8 Treatability Study/Pilot Testing

The need for treatability studies and/or pilot testing was evaluated after the completion of the data validation/evaluation and the initial screening of remedial technologies. Discussion of identified treatability studies and/or pilot testing will be provided in the Feasibility Study Report.

1.3.9 Remedial Investigation Report

Task 9 encompasses the preparation of the Remedial Investigation Report. The RI report includes the results of the previously discussed tasks, including the following:

- Site surface and subsurface conditions
- Extent and nature of soil contamination, if any
- Extent and nature of groundwater contamination, if any
- Analytical data and QA/QC backup
- Results of the public health and environmental assessments

BCM

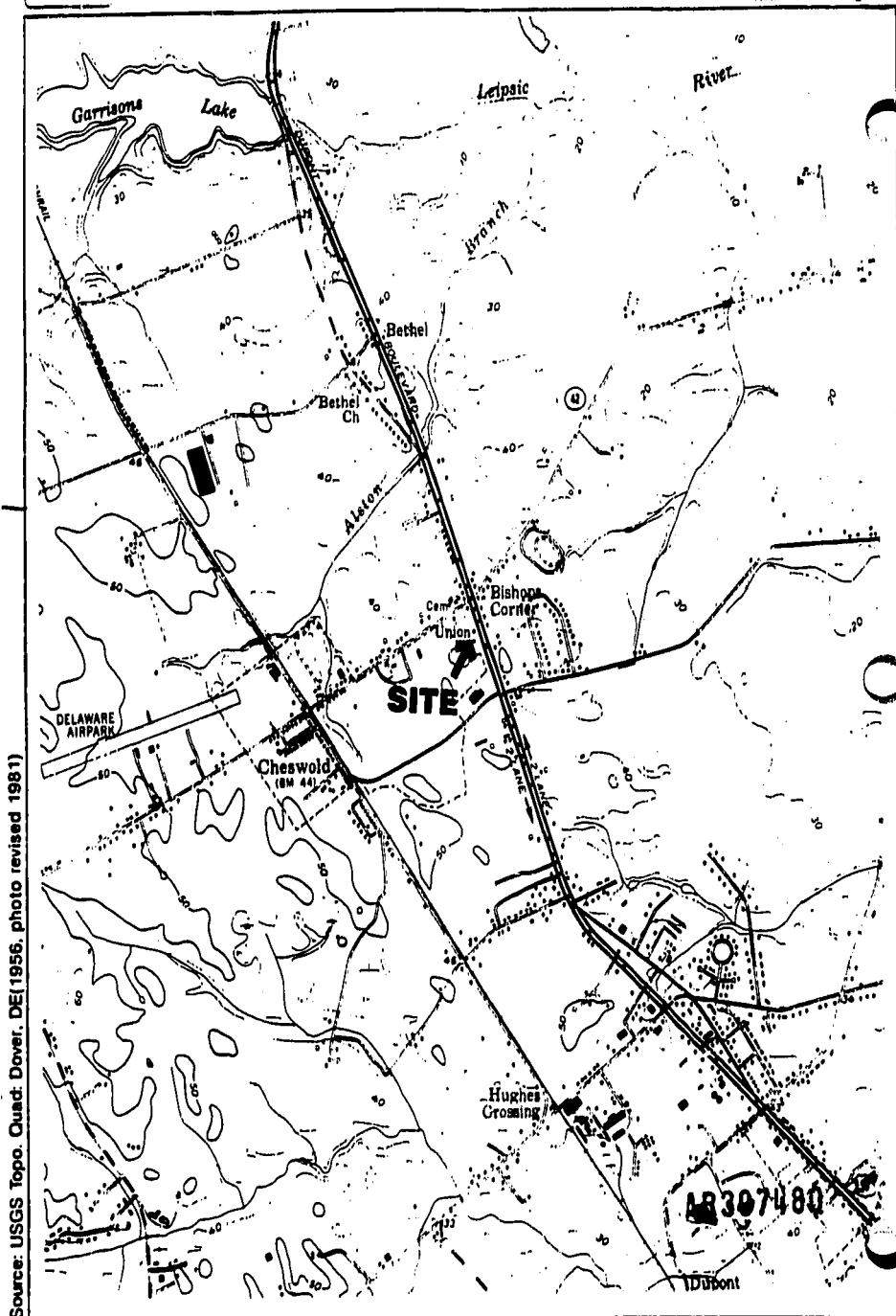
SECTION 1.0
FIGURES

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BCM

CHEM-SOLV. INC. SITE
Remedial Investigation



Source: USGS Topo. Quad: Dover, DE (1956, photo revised 1981)

BCM Project No. 00-8012-02

Figure 1-1
Site Location Map

0 2000 FT NORTH

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LEGEND

- Monitoring Well
 - Property Line
 - ▭ Concrete
 - ▨ Former Concrete Paved Skateboard Park
 - +— Fence
- AR.
- Monitoring Well Meaning, Approximate Location
Source: SMC Martin, 1998
- APPROXIMATE LOCATION OF FORMER EXCAVATION
(SMC MARTIN, 1998)

**Figure 1-2
Site Plan Map**

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SECTION 1.0

TABLES

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TABLE 1-1

SUMMARY OF PAST DNREC
SOIL INVESTIGATION AND CLEANUP ACTIVITIESCHEM-SOLV, INC. SITE REMEDIAL INVESTIGATION
CHESWOLD, DELAWARE

Date	Event
September 1984	Initial soils investigation - Chem-Solv excavated approximately 10 cubic yards of contaminated soil.
April 1985	DNREC excavated 1,300 cubic yards of contaminated soil. Soil was stockpiled onsite.
April 19, 1985	DNREC retained SMC Martin, Inc. (SMC Martin) to evaluate alternatives for soil and groundwater cleanup.
May 1 and 10, 1985	SMC Martin conducted pre-soil shredding soil sampling in the excavation sidewalls and floor, staged soil stockpile, and nearby drainage-way.
May 18, 1985	SMC Martin issued <u>Evaluation of Remedial Alternatives for Soil and Groundwater Cleanup at the Chem-Solv Solvent Recovery Site, Cheswold, Delaware.</u>
August 16, 1985	SMC Martin conducted a round of pre-shredding soil sampling of in-place soil adjacent to the stockpile and of stockpiled soils.
September 9, 1985	Guardian Construction Company began soil shredding process.
November 7, 1985	Soil shredding completed.
November 11, 1985	Post-shredding confirmatory soil sampling completed.
May 20, 1986	SMC Martin issued <u>Removal of Volatile Organic Contaminants from Soils at the Chem-Solv Solvent Recovery Facility, Cheswold, Delaware.</u>

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TABLE 1-2
SUMMARY OF PAST DNREC
GROUNDWATER INVESTIGATION AND CLEANUP ACTIVITIES
CHEM-SOLV, INC. SITE REMEDIAL INVESTIGATION
CHESWOLD, DELAWARE

Date	Event
September 1984	Five groundwater monitoring wells installed in the shallow aquifer. Domestic wells sampled (SMC Martin, 1986).
October 3, 1984	Five monitoring wells sampled.
October 1984	Groundwater table elevations measured twice in five monitoring wells (SMC Martin, 1986).
November 28-30, 1984	Seven monitoring wells installed.
December 5 and 6, 1984	Ten monitoring wells and four domestic wells sampled.
January 29 and 31, 1985	Nine monitoring wells sampled.
April 1985	One monitoring well removed during soil excavation (SMC Martin, 1986).
April 22, 1985	Eleven monitoring wells and six domestic wells sampled.
April 1985 to approx. August 1985	SMC Martin conducted hydrogeologic investigation at site, including slug tests (CABE, 1987).
May 18, 1985	SMC Martin issued <u>Evaluation of Remedial Alternatives for Soil and Groundwater Cleanup at the Chem-Solv Solvent Recovery Site, Cheswold, Delaware.</u>
August 5, 1985	CABE retained to help implement the groundwater recovery and treatment system.

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TABLE 1-2 (Continued)

Date	Event
August 13-22, 1985	Eleven monitoring wells and one recovery well installed.
August 14, 1985	One (of the original five) monitoring well sampled.
August 22, 1985	The eleven monitoring wells most recently installed were sampled.
August 26, 1985	Pump test conducted; pumped and sampled OB-5AR (CABE, 1987).
August 28, 1985	Ten monitoring wells sampled.
September 11, 1985	New domestic well installed at Gearhart property, finished at 50 feet (Appendix D).
September 12, 1985	Four monitoring wells sampled (Attachment J; CABE, 1987).
September 18 and 26, 1985	Nine monitoring wells and one recovery well installed.
October 4, 1985	Eight monitoring wells sampled.
October 9, 1985	One monitoring and one recovery well sampled. Pump test conducted on wells OB-5A, OB-20AR, and OB-32AR (CABE, 1987).
October 24, 1985	Two recovery wells sampled.
October 25, 1985	Pump test conducted on well OB-34AR (CABE, 1987).
October 1985	Three monitoring and four recovery wells installed.
November 26, 1985	Untreated and treated water from the recovery system sampled to test air stripper efficiency.
December 11, 1985	Recovery and treatment system fully operational and completed 24 hours of operation (CABE, 1987).

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TABLE 1-2 (Continued)

Date	Event
January 2, 1986	Untreated and treated water from the recovery system sampled.
February 19, 1986	Thirteen domestic wells sampled (Attachment J; CABE, 1987).
February 27, 1986	Untreated and treated water from the recovery system sampled.
March 11, 1986	Twelve monitoring wells and one domestic well sampled; untreated water from the recovery system also sampled.
April 8, 1986	Untreated and treated water sampled from one domestic well and the recovery system.
April 11, 1986	Untreated and treated water sampled from one domestic well.
April 28, 1986	Untreated and treated water sampled from the recovery system.
May 13, 1986	Nine monitoring wells, untreated and treated water from the recovery system, and untreated water from one domestic well sampled. Attachment J (CABE, 1987) indicates that 13 monitoring wells and untreated and treated water from the recovery system was sampled; untreated water from one domestic well was sampled twice.
June 9, 1986	One recovery well (OB-43AR) installed. This well was later added to the recovery system.
June 10, 1986	One recovery well (OB-44AR) installed. This well was not added to the recovery system; the well was later renamed monitoring well OB-44A.
June 11 and 16, 1986	One monitoring well installed (OB-45B).

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TABLE 1-2 (Continued)

Date	Event
June 18, 1986	Pump test conducted in well OB-45B (CABE, 1987). This well was also sampled.
June 30, 1986	Pump test conducted on OB-43AR (1987, CABE).
July 1986	Carbon point-of-use treatment system installed in home with contaminated domestic well (BCM, 1989).
July 14, 1986	Untreated and treated water from the recovery system and one domestic well sampled.
July 28 and 29, 1986	Sixteen monitoring wells and untreated water from the recovery system sampled.
September 25, 1986	Untreated and treated water from the recovery system sampled.
November 17 and 18, 1986	Sixteen monitoring wells sampled. Three of these wells were sampled by both bailing and pumping. Three domestic wells sampled. Untreated and treated water from one domestic well and from the recovery system sampled.
March 1987	CABE Associates issued final report for DNREC, <u>Groundwater Decontamination, Chem-Solv Solvent Recovery Facility, Cheswold, Delaware.</u>
May 15, 1987	Replacement domestic well installed at Gearhart property (Appendix D)
June 8-16, 1987	Seventeen monitoring and nine domestic wells sampled.
August 1987	Replacement domestic well had been installed at adjacent property (Appendix A-11).
September 4, 1987	Untreated water from the recovery system sampled.

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TABLE 1-2 (Continued)

Date	Event
October 15, 1987	Recovery system untreated water and one domestic well sampled.
December 1, 1987	Recovery system untreated water and one domestic well sampled.
December 17, 1987	Recovery system untreated water sampled.
December 22, 1987	Four monitoring wells and recovery system untreated water sampled.
January 5 and 6, 1988	Five monitoring wells, two domestic wells, and recovery system untreated water sampled.
March 21, 1988	Nine monitoring wells, one domestic well, and recovery system untreated water sampled.
April 14, 1988	Three monitoring wells, one domestic well, and recovery system untreated water sampled.
May 17, 1988, and June 15, 1988	Recovery system untreated water sampled.
July 26, 1988	One monitoring well, five domestic wells, and recovery system untreated water sampled.
September 1988	Air stripping tower collapsed. Continued pumping groundwater from the recovery system to the Kent County sewer system.
November 15, 1988	One monitoring well, five domestic wells, and recovery system untreated water sampled.
November 1988	Discharging of groundwater from the recovery system to sewer system halted.

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TABLE 1-3

SUMMARY OF REGULATORY ACTIVITIES

CHEM-SOLV, INC. SITE REMEDIAL INVESTIGATION
CHESWOLD, DELAWARE

Date	Event
January 22, 1987	Chem-Solv, Inc. Site initially proposed for inclusion on the National Priorities List (NPL) (52 FR 2492).
June 24, 1988	Chem-Solv, Inc. Site repropoed for inclusion on the NPL (53 FR 23988).
September 1988	DNREC, EPA, and Chem-Solv signed Administrative Order signed on Consent.
September 1988	BCM retained to conduct Remedial Investigation/Feasibility Study.
December 1988	BCM issued <u>Draft Remedial Investigation/Feasibility Study, Work Plan for the Chem-Solv Site, Cheswold, Delaware.</u>
December 1, 1989	RI/FS Work Plan was approved by DNREC and EPA.
December 4, 1989	BCM began implementation of the RI/FS Work Plan.
August 30, 1990	Chem-Solv, Inc. site formally included on NPL, Site No. 573 (55 FR 35502)

Source: BCM Engineers Inc. (BCM Project No. 00-6012-02)

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SECTION 20

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2.0 REMEDIAL INVESTIGATION METHOD

2.1 AIR INVESTIGATION

BCM conducted an air investigation to evaluate health and safety needs at the site before initiating sampling or any intrusive activities. Data from this investigation were also used to estimate onsite and offsite exposure as part of the site Endangerment Assessment.

The investigation was conducted on October 16, 1989. Twelve sampling locations were set up around the perimeter of the site (Figure 2-1). Ambient organic vapor readings were recorded at each location using both an HNu Systems Photoionization Detector (HNu PI-101, 10.2 eV probe) and a Century Systems Organic Vapor Analyzer (OVA-128). At each location, the HNu and OVA instrument probes were directed inward, towards the former excavated area.

Air monitoring with either the HNu or the OVA and a combustible gas/oxygen/hydrogen sulfide meter (MSA Model 361) was also performed continuously during all intrusive drilling activities. Air monitoring using either the HNu or the OVA was performed continuously during well construction, well development, groundwater sampling, and water level measurement activities.

All monitoring equipment was calibrated to gas standards each day before use and recorded in a bound field-log book. The OVA was calibrated with methane and inert nitrogen gas (86.5 parts per million [ppm] methane). The HNu was calibrated with isobutylene and inert nitrogen gas (95.9 ppm isobutylene). The combustible gas/oxygen/hydrogen sulfide meter was calibrated with methane/oxygen and inert nitrogen gas (1.4 percent methane, 15.6 percent oxygen).

2.2 SOILS INVESTIGATION

This investigation was designed to characterize soils near areas where hazardous materials had either been stored or were suspected of having been stored. Eight borings from seven locations were placed around the edge of the former excavated area and the remaining concrete pad. Three soil samples from each location were retained for chemical analyses. In addition, split samples were retained for the EPA by personnel from CDM Federal Programs Corporation (FPC) and submitted for chemical analyses.

The soils investigation was conducted from December 4 through December 20, 1989, and from February 22 through February 28, 1990. Because of extreme weather conditions encountered during December 1989, work at the site was halted December 20, 1989. Freezing temperatures

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hampered decontamination of the sampling equipment and raised questions about the possibility of cross contamination of the soil samples. BCM notified DNREC of the work stoppage in a letter dated December 27, 1989 (Appendix A-4). DNREC approved the work stoppage in a letter dated January 22, 1990 (Appendix A-5).

Generally, field activities were conducted in accordance with the procedures contained in the Work Plan. Some modifications to the Work Plan were necessary because of conditions encountered during the investigation; these modifications are detailed in the following sections.

2.2.1 Sample Locations

Eight borings (CSB-6, CSB-7, CSB-8, CSB-8A, CSB-9, CSB-10, CSB-11, and CSB-12) were placed at seven locations outside the edges of the former excavated area (Figure 2-2). Boring logs are contained in Appendix E. The soil in the former excavation area delineates the soils from around the former distillation building that were excavated, shredded, tested for indicator parameters, and placed back in the excavation during work performed by DNREC in 1985 before the RI. Because the soil was excavated to the top of the water table, the RI soil investigation was structured to delineate what contaminants, if any, remained in the unsaturated soils outside the excavation. A description of each boring location and the rationale for placement of the boring are provided below.

<u>Boring Name</u>	<u>Location Description</u>	<u>Location Rationale</u>
CSB-6	Southeastern side of excavation	Delineate soils south of the former distillation building
CSB-7	South-central side of excavation	Delineate soils south of the former distillation building
CSB-8 CSB-8A	Southwestern edge of concrete pad	Delineate possible soil contamination due to runoff from former drum storage pad
CSB-9	Northwestern edge of concrete pad	Delineate possible soil contamination due to runoff from former drum storage pad
CSB-10	Eastern edge of concrete pad	Delineate possible soil contamination due to runoff from former drum storage pad
CSB-11	North-central edge of concrete pad	Delineate soils north of former distillation building



CSB-12

Between concrete
pad and concrete
block building

Delineate soils north of
former distillation building

Boring B-8 was abandoned at 16 feet because of difficulties keeping the borehole open during drilling; Boring B-8A was then drilled as a replacement boring for that location.

2.2.2 Sampling Protocol

2.2.2.1 Soil Samples

The soil borings were drilled to depths ranging from 20 feet to 26 feet using a rotary drilling rig with 3-1/4-inch and 6-1/4-inch inside-diameter (ID) hollow-stem augers. Soil cores were obtained continuously throughout the soil borings using 2-foot-long, 2-inch or 3-inch outside-diameter (OD) carbon steel split-spoon samplers. The split spoons were driven using a 140-pound hammer.

As described in the Work Plan, the soil borings were to be completed to the top of the silt layer, if present, or to a maximum depth of 35 feet; split-spoon samples were retained continuously throughout the boring column for lithologic descriptions and for chemical analyses. Two soil samples from each boring location were to be retained from the unsaturated zone and submitted for Target Compound List (TCL) organic and Target Analyte List (TAL) inorganic parameters. Soil samples were to be collected from the 0.5-foot to 2-foot interval and the 2-foot interval just above the top of the water table, unless elevated organic vapor readings were recorded from head space analyses. If elevated organic readings were encountered, the sample intervals were to be selected from the intervals with the highest levels. In addition, if the silt layer was encountered, one soil sample from the interval just above the silt was to be analyzed for TCL volatile compounds.

2.2.2.2 Field Quality Control Samples

Field rinsate blanks, trip blanks, and field duplicate samples were submitted for chemical analyses with the soil samples in accordance with the protocol detailed in Section 9.2 of the Quality Assurance Project Plan (QAPJP).

2.2.3 Analytical Parameters and Methods

Twenty-three samples were submitted for chemical analyses. Of these samples, two were field duplicate samples. A sample summary table presenting the soil sample locations, depths, and analytical parameters is presented as Table 2-1. Sixteen samples were submitted to the Industrial and Environmental Analysts, Inc. (IEA) laboratory in Cary, North Carolina, for TCL organic and TAL inorganic analyses. Seven soil samples were submitted to IEA for TCL organic analyses.

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All analyses were performed in accordance with the procedures contained in the Work Plan and the QAPJP. In addition, BCM performed a laboratory audit for inorganic analyses on December 19, 1990. The laboratory audit report was submitted to DNREC on January 4, 1990 (Appendix A-6).

2.3 STRATIGRAPHIC INVESTIGATION

The stratigraphic investigation was conducted to provide offsite lithologic information, specifically to delineate the horizontal extent of the silt layer present at approximately 20 feet below the site. Five stratigraphic borings (CSB-1 through CSB-5) were drilled to a maximum depth of 43 feet. Boring logs for the stratigraphic borings are contained in Appendix E. In addition, two Shelby tube samples of the silt layer were obtained from Borings CSB-1 and CSB-4; these samples were analyzed for physical parameters (Table 2-1).

The stratigraphic borings were drilled from December 4 through 7, 1990, and from February 28 through March 8, 1990. Generally, the borings were conducted in accordance with the specifications contained in the Work Plan. Any deviations or modifications are addressed below.

2.3.1 Sample Locations

The stratigraphic borings were located along a line approximately parallel to the axis of the groundwater flow direction (Figure 2-2). A list of the boring locations and a description of the location rationale are presented below.

<u>Boring Name</u>	<u>Location Description</u>	<u>Location Rationale</u>
CSB-1	Southwestern edge of property	Upgradient position
CSB-2	American Roofing and Siding Co. property	Downgradient position
CSB-3	Durham property	Farthest downgradient position
CSB-4	Lambertson property	Nearest downgradient position
CSB-5	Route 13 median near Well 39A	Downgradient position

Field boring locations were discussed with and approved by DNREC before field activities began.

2.3.2 Sampling Protocol

The soil borings were drilled using 3-1/4-inch, 4-1/4-inch, and 6-1/4-inch hollow-stem augers. Soil cores were obtained from each boring beginning at 10 feet using 2-foot-long 2-inch OD split spoons; the cores were obtained continuously from 10 feet to the bottom of the borehole, which was either the base of the silt layer or 35 feet if the silt layer was not encountered.

All split-spoon samples were scanned with an HNu or OVA as they were removed from the borehole and after each spoon was opened. Organic vapor readings from these scans are contained in the boring logs in Appendix D. In addition, head space readings were obtained for each sample.

Samples of the silt layer were obtained from CSB-1 and CSB-4 using 3-inch-OD thin-walled Shelby tube samplers. These samples were analyzed at the Woodward-Clyde Laboratory in Plymouth Meeting, Pennsylvania, for vertical coefficient of permeability and grain size distribution. Because the silt layer was not encountered at the other locations, no Shelby tube samples were obtained from those borings.

2.3.3 Analytical Parameters and Methods

Samples CSB-1 (22-24) and CSB-4 (22-24) were analyzed for vertical coefficient of permeability and grain size distribution using ASTM reference methods. Immediately upon retrieval, both ends of the Shelby tube sampler were sealed with wax; the tubes were stored upright and delivered to the Woodward-Clyde Laboratory for analysis.

2.4 GROUNDWATER INVESTIGATION

The groundwater investigation included the installation of 7 offsite monitoring wells and chemical analyses of groundwater from 14 onsite and offsite locations. Seven monitoring wells were installed from December 6, 1989, through March 12, 1990. Of these wells, four were designed to monitor the shallow sand aquifer and three were designed to monitor groundwater in the intermediate zone of the aquifer beneath the silt layer.

2.4.1 Monitoring Well Installation

Seven monitoring wells were completed as part of the remedial investigation (Figure 2-2). They were installed to provide additional information needed to more completely delineate the horizontal and vertical extent of the groundwater contaminant plume associated with the site. In addition, the wells may be used for future monitoring of the plume, if necessary.

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2.4.1.1 Monitoring Well Designations and Locations

Well identification numbers (e.g., MWS-6-25) consist of four components. The first component ("MW") designates a monitoring well. The second component designates the aquifer zone monitored by the well; "S" designates a shallow-zone well, and "I" designates an intermediate-zone well. The third component is a number from 1 through 7 indicating the location designation of the well. The fourth component is the bottom depth of the screened interval in that well.

A summary of the monitoring well locations, well depth, and location rationale is presented below.

<u>Well Name</u>	<u>Location Description</u>	<u>Location Rationale</u>
MWI-1-43	Southwestern corner of property	Upgradient, intermediate aquifer zone
MWI-2-40	American Roofing and Siding Co. property	Downgradient, intermediate aquifer zone
MWS-3-17	American Roofing and Siding Co. property	Downgradient, shallow aquifer zone
MWI-4-40	Durham property	Downgradient, intermediate aquifer zone
MWS-5-18	Durham property	Downgradient, shallow aquifer zone
MWS-6-25	Stein property north of former Mobil Station	Downgradient, shallow aquifer zone
MWS-7-25	Route 13 median north of Route 42 intersection	Downgradient, shallow aquifer zone

Monitoring well locations were selected in the field with the approval of DNREC before field activities began.

2.4.1.2 Monitoring Well Construction

Shallow Zone Wells

Shallow monitoring wells were drilled using 6-1/4-inch-ID hollow stem augers. Soil cores were retained continuously throughout the boring using 2-inch-OD split-spoon samplers; these cores were scanned with an HNu and/or an OVA. Lithologic descriptions for each well are included in the well logs contained in Appendix F.

The specifications for the shallow-zone monitoring wells were designed to provide information about the sand aquifer above the silt layer. The wells were to be screened above the silt layer, if present. If the silt layer was not encountered at a location, the well would be constructed to screen a 10-foot interval from 15 feet to 25 feet below the ground surface. A schematic representation of monitoring well construction detail is shown on Figure 2-3.

After each boring was advanced to the required depth, the monitoring well was constructed using 2-inch-ID schedule-40 polyvinyl chloride (PVC) casing and screen. All well screens were factory-slotted with 0.010-inch or 0.020-inch slots; the 0.010-inch screens were installed at locations where the aquifer contained significant fine material. The casing, screen, and bottom cap were connected with threaded flush joints; no glue was used. Between 7 and 10 feet of screen were used in each well, depending on lithologic conditions. The annulus (void between the well casing or screen and the boring wall) was packed to at least 1 foot above the screen with clean silica sand.

A bentonite pellet seal was placed on top of the sand pack, and the remainder of the hole was filled with a cement-bentonite grout. A locking protective steel casing was inserted a minimum of 3 feet into the grouted annulus.

Intermediate-Zone Monitoring Wells

Section 4.5.2 of the Work Plan contains specifications for the construction of the three intermediate-zone monitoring wells. However, only well MHI-1-43 was constructed as proposed in the Work Plan. The silt layer was not encountered or was too thin to seal off with an outer steel casing in the other two wells (MHI-2-40 and MHI-4-40). A schematic representation of monitoring well detail is shown on Figure 2-3.

To determine the depth and thickness of the silt layer at the MHI-1-43 location, a stratigraphic boring (CSB-1) was drilled using 6-1/4-inch hollow-stem augers. This boring was abandoned and grouted to the surface. Well MHI-1-43 was then drilled using the mud rotary drilling method. A 10-inch diameter borehole was drilled to the top of the silt at 23 feet. A 6-inch steel outer casing was then driven 1 foot into the

silt layer and set at 24 feet; the annulus between the casing and the borehole was tremie grouted with a cement-bentonite mixture. After the grout was allowed to set overnight, the boring was advanced to 43 feet (15 feet below the bottom of the silt layer). The well was constructed using 10 feet of 2-inch-ID schedule-40 PVC with 0.020-inch screen. A filter pack consisting of No. 1 Jessie Morie sand was installed from the base of the borehole to 31 feet. An 8-foot-thick granular bentonite seal was installed above the filter pack; the annular space above the seal was tremie grouted with a cement-bentonite mixture.

Wells MWI-2-40 and MWI-4-40 were installed using specifications similar to those for shallow-zone wells. Because the silt layer was not encountered at those locations, no outer steel casing was installed. Both wells were constructed using 10 feet of 0.010-inch screen which was set to a depth of 30 feet to 40 feet below the ground surface. Before modifying the well specifications, BCM contacted DNREC and received approval of these changes.

2.4.1.3 Monitoring Well Development

All monitoring wells were developed by overpumping with a centrifugal pump. As detailed in Section 4.5.4 of the Work Plan, each well was developed for a maximum of 1 hour or until sediment-free flow was obtained. Only one well (MWI-4-40) was developed for less than 1 hour.

Several of the wells were also surged with a 5-foot-long, 1-1/2-inch-diameter PVC slug; the slug was moved up and down in the well to allow water to move into and out of the well through the well screen.

Development water was discharged into 55-gallon drums. Organic vapor readings were measured in the drum headspace using an OVA. According to the Work Plan, development water was to be discharged directly to the ground unless elevated organic vapor readings were found. Sustained organic vapor measurement greater than the background levels were considered to be elevated readings. No sustained OVA readings above ground were encountered during the development of any well. Therefore, this water was discharged to the ground.

2.4.2 Groundwater Sampling

Groundwater samples were retained for chemical analyses from 14 locations from April 4 through 9, 1990. In addition, split samples were retained from 3 wells for analyses by FPC personnel. A groundwater sample summary, including well name, sampling method, and analyses performed, is presented as Table 2-2. Several modifications to the groundwater sampling protocol described in Section 4.5.5 of the Work Plan were made. Before sampling began, BCM submitted an addendum to the Work Plan to DNREC on April 1, 1990 (Appendix A-7). Modifications contained in the Work Plan Addendum are discussed in the following sections.

Fourteen monitoring wells were sampled from February 19 through 21, 1991; split samples from two wells were retained for analyses by FPC personnel. A groundwater sample summary is presented in Table 2-3. The samples were collected and analyzed in accordance with the method discussed in the Work Plan and the Sampling Plan.

DNREC sampled three domestic wells (American Roofing, Gearhart/Shane, and Simon) and one monitoring well (39A) on March 4, 1991. All four wells were analyzed by the DNREC laboratory for volatile organic compounds; the domestic wells were also analyzed for mercury, manganese, and zinc.

2.4.2.1 Sampling Locations

Groundwater samples were obtained in April 1990 from eight offsite shallow wells (22A, 26A, 39A, 41A, MWS-3-17, MWS-5-18, MWS-6-25, and MWS-7-25), one onsite shallow well (33A), two onsite intermediate wells (5B and 9B), and three offsite intermediate wells (MWI-1-43, MWI-2-40, and MWI-4-40). In addition, field duplicate samples were obtained from wells 26A and 9B. Split samples were obtained by FPC personnel from Wells 41A, MWS-5-18, and 9B; a field duplicate was also obtained from Well 9B. A groundwater sample summary for the EPA split samples is contained in Table 2-2.

These sampling locations were selected to provide groundwater quality information for several areas of the sand aquifer. The eight offsite shallow wells were used to characterize the magnitude and extent of the contaminated slug of groundwater that apparently exists downgradient of the site in the shallow zone. Data generated from the five intermediate wells were used to evaluate the magnitude and extent of contamination in the intermediate zone beneath the silt layer. Data from the shallow onsite well were used to evaluate the magnitude of contamination remaining onsite in the shallow zone.

Of these wells, 33A and 41A were not included in the sampling program contained in Section 4.5.5 of the Work Plan. Well 33A was sampled instead of the recovery system; the recovery system pump could not be started because of rust. BCM and DNREC agreed to the selection of Well 33A as an alternative to the recovery system on April 9, 1990. Well 41A was included in the sampling as a replacement location for Well 28A, which has been paved over with asphalt (Appendix A-7).

2.4.2.2 Sampling Protocol

Groundwater Samples

Wells were sampled in accordance with the procedures detailed in the Work Plan, the Work Plan Addendum, and the Sampling Plan. Because of the diameter of many of the DNREC monitoring wells (0.5-inch ID), these wells were purged and sampled using a peristaltic pump; wells with sufficiently large diameter were sampled using 2-inch-OD Teflon tubing. AR 301499

Tables 2-2 and 2-3 provide a list of the purge and sampling methods used during the April 1990 and February 1991 sampling events, respectively.

All volatile samples, except for trip blanks, were preserved with hydrochloric acid in the field by BCM personnel. Inorganic analyses were performed on both unfiltered and filtered samples at all locations. The samples were filtered in the field using a nitrogen pressure filtering unit with a 0.45-micron filter.

Field Quality Control Samples

Field rinsate blanks, trip blanks, and field duplicate samples were retained and submitted for analyses in accordance with the procedures detailed in Section 9.2 of the QAPJP.

2.4.2.3 Analytical Parameters and Methods

All groundwater samples obtained in April 1990 were analyzed for TCL organic compounds and TAL inorganic compounds by IEA. Analyses were performed in accordance with the protocol contained in Attachment 5 of the QAPJP.

2.4.3 Well Elevation Survey

A site survey had been conducted for DNREC by Robert L. Larimore of Wyoming, Delaware, on March 11, 1986. This survey was used to construct the site maps included in the Work Plan. A summary of the well specifications for all monitoring wells installed by DNREC, including total depth, reference elevation, and status, is provided in Table 2-4.

J.G. Park Associates, Inc. (J.G. Park) of Washington Crossing, Pennsylvania, conducted a survey to determine the horizontal location and vertical reference elevations of the seven monitoring wells. The survey was performed on June 4 and June 5, 1990. The reference elevations for the seven monitoring wells installed as part of this remedial investigation are provided on Table 2-5.

In addition to locating the newly installed monitoring wells, J.G. Park delineated site topography. A topographic contour map, with 1-foot topographic contours, was constructed for this purpose. J.G. Park also surveyed the existing onsite monitoring wells (horizontal location only), the existing onsite buildings, and Routes 13 and 42 in the vicinity of the site. Information from both surveys was combined to construct the site maps included in this report.



2.4.4 Water Level Measurements

To determine the hydraulic head distribution in the shallow and intermediate aquifer zones, four rounds of water-level data were collected from all accessible monitoring wells. The water level measurements were obtained on March 27, 1990, April 4, 1990, February 19, 1991, and April 5, 1991, for all existing monitoring wells.

The water level measurements were obtained in accordance with the procedures contained in Section 4.5.6 of the Work Plan. A summary of the measurement procedures follows:

- The well cap was opened and the well head organic vapor readings were recorded using either an OVA or an HNU.
- Depth-to-water measurements were recorded from the top of the inner casing (or from the top of the outer casing if only one casing was present) using an electronic water-level instrument.
- As the probe and the cable of the electronic water-level recording instrument were removed from the well, they were scrubbed with a solution of soap and deionized water and then rinsed with deionized water to prevent cross contamination between the wells.
- The well name, OVA or HNs reading, time, and depth-to-water were recorded in a bound field book, which is stored in BCM central files.

Potentiometric surface contour maps were constructed for the shallow and the intermediate aquifers for all four dates. Groundwater elevation data were calculated from the water-level measurements and well reference locations; these data were then plotted on a map at the appropriate location, and contour lines were plotted. An evaluation of these data is presented in Section 3.2.2.

BCM

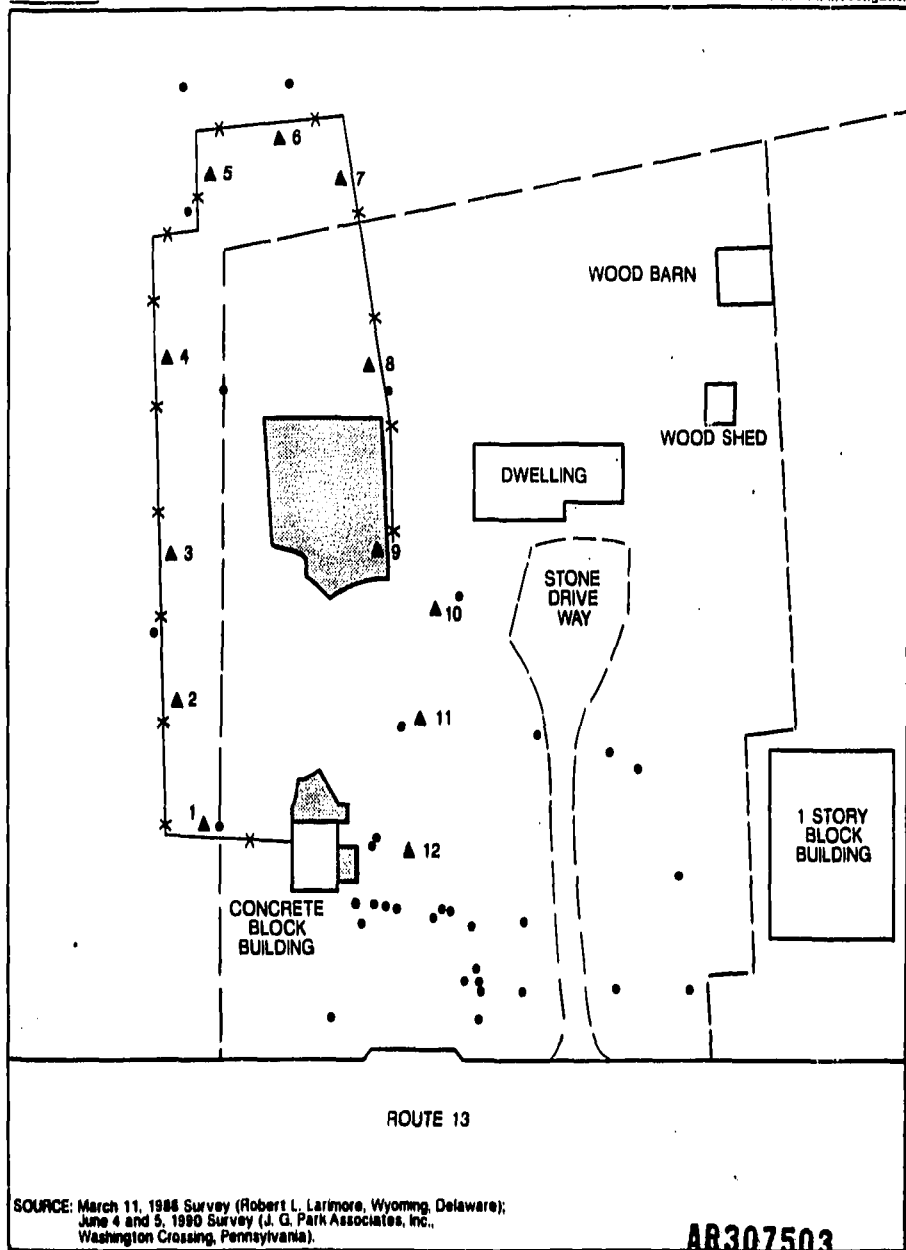
SECTION 2.0
FIGURES

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BCM

CHEM-SOLV, INC. SITE
Remedial Investigation



BCM Project No. 00-8012-02

LEGEND

• Monitoring Well

— Property Line

Concrete

1 ▲ Air Monitoring Location

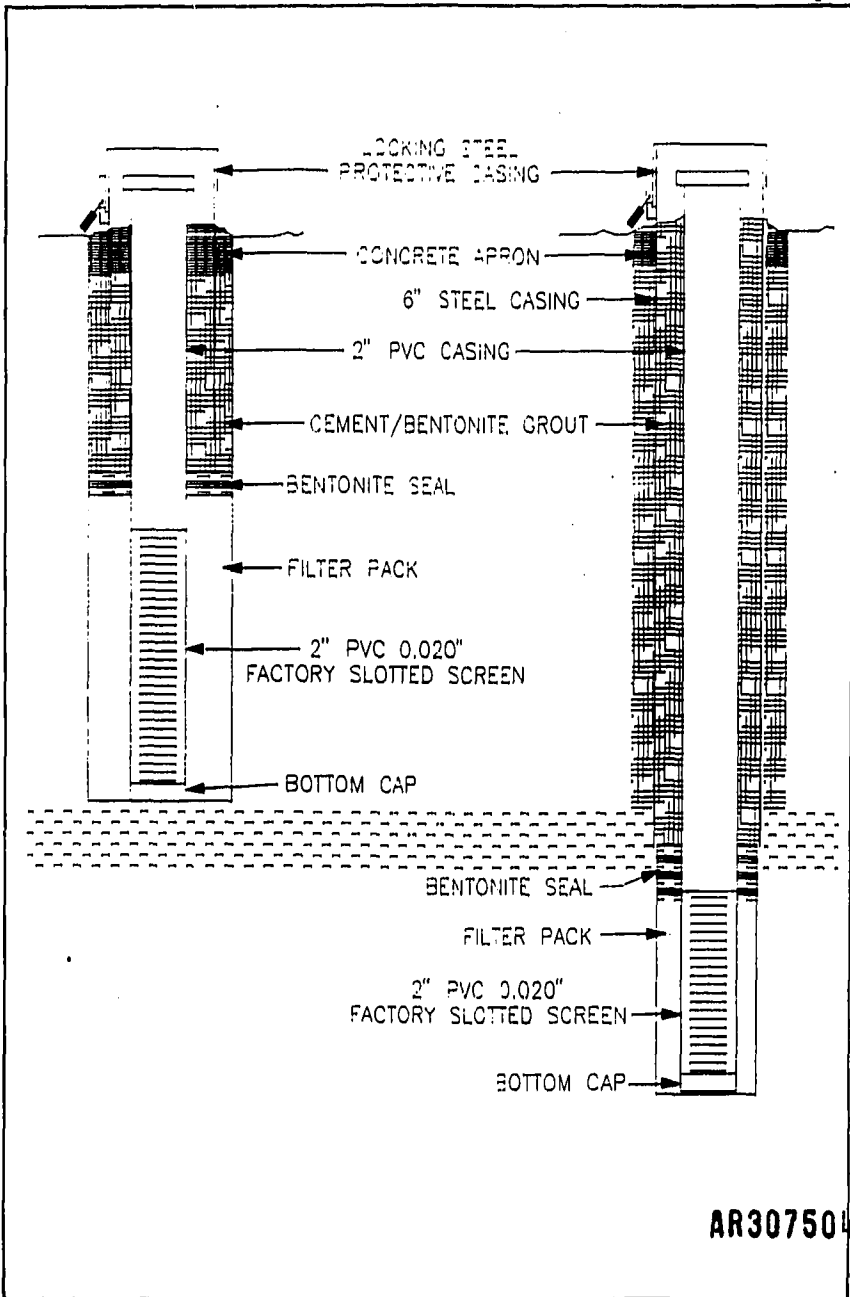
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NORTH

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Figure 2-1
Onsite Perimeter Air
Monitoring Locations

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BCM Project No. 00-6012-02

NOT TO SCALE

Figure 2-3
Monitoring Well
Construction Detail

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ECM

SECTION 2.0
TABLES

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TABLE 2-1

SOIL SAMPLING SUMMARY

CHEM-SOLV, INC. SITE REMEDIAL INVESTIGATION
CHESWOLD, DELAWARE

Sample Name*	Sample Date	Analytical Parameters
CSB-1 (22-24)	12/05/89	Grain size; coefficient of permeability
CSB-4 (20-22)	03/07/90	Grain size; coefficient of permeability
CSB-6 (0.5-2)	12/14/89	TCL Organics; TAL Inorganics
CSB-6 (6-7.3)	12/14/89	TCL Organics; TAL Inorganics
CSB-6 (19.6-19.9)	12/15/89	TCL Volatile Organics
CSB-7 (4-6)	12/13/89	TCL Organics; TAL Inorganics
CSB-7 (8-10)	12/13/89	TCL Organics; TAL Inorganics
CSB-7 (20.5-20.8)	12/14/89	TCL Volatile Organics
CSB-8 (0.5-2)**	02/22/90	TCL Organics; TAL Inorganics
CSB-8D (0.5-2)**	02/22/90	TCL Organics; TAL Inorganics
CSB-8 (2-4)	02/22/90	TCL Organics; TAL Inorganics
CSB-8A (18-20)	02/26/90	TCL Volatile Organics
CSB-9 (2-4)	02/27/90	TCL Organics; TAL Inorganics
CSB-9 (4-5.5)	02/27/90	TCL Organics; TAL Inorganics
CSB-9 (19.5-20)	02/27/90	TCL Volatile Organics
CSB-10 (0.5-2)	02/27/90	TCL Organics; TAL Inorganics
CSB-10 (2-4)**	02/27/90	TCL Organics; TAL Inorganics
CSB-10 (18-18.5)**	02/27/90	TCL Volatile Organics
CSB-11 (0.5-2)	12/19/89	TCL Organics; TAL Inorganics
CSB-11D (0.5-2)	12/19/89	TCL Organics; TAL Inorganics
CSB-11 (6-8)	12/19/89	TCL Organics; TAL Inorganics
CSB-11 (20.4-20.7)	12/20/89	TCL Volatile Organics
CSB-12 (0.5-2)	12/18/89	TCL Organics; TAL Inorganics
CSB-12 (2-4)	12/18/89	TCL Organics; TAL Inorganics
CSB-12 (21.7-22)	12/19/89	TCL Volatile Organics

* Sample name denotes the boring location and the depth, in feet, below the ground surface, that the sample was obtained from.

** EPA split sample provided to personnel from CDM Federal Programs Corporation for analyses.

TAL Target analyte list

TCL Target compound list

Source: BCM Engineers Inc. (BCM Project No. 00-6012-02)

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TABLE 2-2
GROUNDWATER SAMPLING SUMMARY
APRIL 1990
CHEM-SOLV, INC. SITE REMEDIAL INVESTIGATION
CHESWOLD, DELAWARE

Well Sampled*	Purge Method	Sample Method	Date Sampled	Analytical Parameters***
BCM	FPC			
22A	Peristaltic pump	Peristaltic pump	04/04/90	TCL Organics; TAL Inorganics
26A**	Peristaltic pump	Peristaltic pump	04/05/90	TCL Organics; TAL Inorganics
32A	Peristaltic pump	Peristaltic pump	04/09/90	TCL Organics; TAL Inorganics
39A	Peristaltic pump	Peristaltic pump	04/05/90	TCL Volatile Organics
	Peristaltic pump	Peristaltic pump	04/09/90	TCL Organics (except volatiles); TAL Inorganics
41A	Peristaltic pump	Peristaltic pump	04/05/90	TCL Organics; TAL Inorganics
5B	Centrifugal pump	Peristaltic pump	04/04/90	TCL Organics; TAL Inorganics
9B**	Centrifugal pump	Teflon bailer	04/06/90	TCL Organics; TAL Inorganics
MW-1-43	Centrifugal pump	Teflon bailer	04/09/90	TCL Organics; TAL Inorganics
MWS-2-40	Centrifugal pump	Teflon bailer	04/06/90	TCL Organics; TAL Inorganics
MWS-3-17	Centrifugal pump	Teflon bailer	04/06/90	TCL Organics; TAL Inorganics
MW-4-40	Centrifugal pump	Teflon bailer	04/05/90	TCL Organics; TAL Inorganics
MWS-5-18	Centrifugal pump	Teflon bailer	04/05/90	TCL Organics; TAL Inorganics
MWS-6-25	Centrifugal pump	Teflon bailer	04/06/90	TCL Organics; TAL Inorganics
MWS-7-25	Centrifugal pump	Teflon bailer	04/05/90	TCL Organics; TAL Inorganics

* Split samples from 3 wells provided to personnel from CDM Federal Programs Corporation

** Field duplicate samples obtained at these locations

*** pH, specific conductance, and temperature measured in field prior to sample collection

- Not sampled

TCL Target Compound List

TAL Target Analyte List (Filtered and unfiltered samples)

Source: BCM Engineers Inc. (BCM Project No. 00-6012-02)

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TABLE 2-3

GROUNDWATER SAMPLING SUMMARY
FEBRUARY 1991CHEM-SOLV, INC. SITE REMEDIAL INVESTIGATION
CHESWOLD, DELAWARE

Well Sampled*		Purge Method	Sample Method	Date Sampled	Analytical Parameters ***
BCM	FPC				
16A	--	Peristaltic pump	Peristaltic pump	02/21/91	WCP
18A	--	Peristaltic pump	Peristaltic pump	02/21/91	WCP
22A	--	Peristaltic pump	Peristaltic pump	02/20/91	WCP
24A	--	Peristaltic pump	Peristaltic pump	02/21/91	WCP
26A	26A	Peristaltic pump	Peristaltic pump	02/19/91	TCL Volatiles, TAL Mn, and WCP
33A **	33A	Peristaltic pump	Peristaltic pump	02/19/91	TCL Volatiles, TAL Mn and Zn, and WCP
39A	--	Peristaltic pump	Peristaltic pump	02/20/91	TAL Mn and WCP
41A	--	Peristaltic pump	Peristaltic pump	02/19/91	TCL Volatiles
48A	--	Peristaltic pump	Peristaltic pump	02/20/91	WCP (except nitrate and nitrite)
		Peristaltic pump	Peristaltic pump	02/21/91	Nitrate and nitrite
5A	--	Centrifugal pump	Teflon bailer	02/20/91	WCP
5B	--	Centrifugal pump	Peristaltic pump	02/20/91	WCP
9A **	--	Centrifugal pump	Teflon bailer	02/20/91	TAL Hg, inorganic Hg, and WCP
9B	9B **	Centrifugal pump	Teflon bailer	02/20/91	TAL Hg, inorganic Hg, and WCP
MWI-1-43	--	Centrifugal pump	Teflon bailer	02/20/91	WCP

* Split samples from 3 wells provided to personnel from CDM Federal Programs Corporation

** Field duplicate samples obtained at these locations

*** pH, specific conductance, and temperature measured in field prior to sample collection

-- Not sampled

TCL Target Compound List

TAL Target Analyte List (filtered and unfiltered samples)

WCP Wet chemistry parameters (ammonia, BOD, COD, chloride, nitrate, nitrite, sulfate, and sulfide) and dissolved oxygen

Source: BCM Engineers Inc. (BCM Project No. 00-8012-02)

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TABLE 2-4
WELL SPECIFICATIONS
DOMESTIC WELLS AND DNREC MONITORING WELLS
CHEM-SOLV, INC. SITE REMEDIAL INVESTIGATION
CHESWOLD, DELAWARE

WELL	DRILLER	DATE INSTALLED	DIAMETER (inches)	MATERIAL (casing/screen)	SCREEN LENGTH (feet)	TOTAL DEPTH (feet)	REFERENCE ELEVATION (ft., NGVD)	FINAL SERVICE	STATUS AS OF 04/90
1A	Handex	06/27/84	4.0	pvc/pvc	15.0	20.0	45.58	Monitoring	Destroyed
2A	Handex	06/27/84	4.0	pvc/pvc	10.0	17.0	46.00	Monitoring	Active
3A	Handex	06/27/84	4.0	pvc/pvc	10.0	18.0	46.88	Monitoring	Active
4A	Handex	06/27/84	4.0	pvc/pvc	10.0	17.0	47.49	Monitoring	Active
5A	Handex	06/27/84	4.0	pvc/pvc	10.0	17.0	45.42	Monitoring	Active
5AR	Earth Data	08/20/85	4.0	steel/pvc	10.0	20.0	44.65	Recovery	Active
5B	Earth Data	08/12/85	1.5	steel/pvc	20.0	50.0	45.63	Monitoring	Active
6B	Burns	11/29/84	4.0	pvc/pvc	10.0	40.0	46.27	Monitoring	Active
7A	Burns	11/30/84	4.0	pvc/pvc	10.0	18.0	40.80	Monitoring	Missing
7B	Burns	11/30/84	4.0	pvc/pvc	10.0	50.0	41.15	Monitoring	Missing
8A	Burns	11/29/84	4.0	pvc/pvc	10.0	18.0	42.30	Monitoring	Active
8B	Burns	11/29/84	4.0	pvc/pvc	10.0	50.0	42.30	Monitoring	Active
8C	Burns	11/29/84	4.0	pvc/pvc	10.0	25.0	46.24	Monitoring	Active
9A	Burns	11/29/84	4.0	pvc/pvc	10.0	50.0	46.00	Monitoring	Active
9B	Burns	11/29/84	4.0	pvc/pvc	10.0	17.5	43.46	Monitoring	Active
10A	Earth Data	08/16/85	0.5	steel/pvc	1.5	17.5	43.45	Monitoring	Active
11A	Earth Data	08/16/85	0.5	steel/pvc	1.5	17.5	43.32	Monitoring	Destroyed*
12A	Earth Data	08/16/85	0.5	steel/pvc	1.5	17.5	45.43	Monitoring	Active
13A	Earth Data	08/13/85	0.5	steel/pvc	1.5	17.5	44.86	Monitoring	Active
14A	Earth Data	08/13/85	0.5	steel/pvc	1.5	17.5	45.80	Monitoring	Active
15A	Earth Data	08/22/85	0.5	steel/pvc	1.5	17.0	43.83	Monitoring	Active
16A	Earth Data	08/22/85	0.5	steel/pvc	1.5	17.5	45.24	Monitoring	Active
17A	Earth Data	08/22/85	0.5	steel/pvc	1.5	17.0	47.28	Monitoring	Destroyed*
18A	Earth Data	08/22/85	0.5	steel/pvc	1.5	17.0	46.68	Monitoring	Active
19A	Earth Data	08/22/85	0.5	steel/pvc	1.5	17.0	43.97	Recovery	Active
20AR	Earth Data	08/18/85	1.25	steel/pvc	10.0	18.5	UN	Monitoring	Destroyed
21A	Earth Data	08/18/85	0.5	steel/pvc	1.5	17.0	48.11	Monitoring	Active
22A	Earth Data	08/18/85	0.5	steel/pvc	1.5	17.0	42.90	Monitoring	Destroyed*
23A	Earth Data	08/28/85	0.5	steel/pvc	1.5	17.0	42.47	Monitoring	Active
24A	Earth Data	08/28/85	0.5	steel/pvc	1.5	17.5	42.68	Monitoring	Active
25A	Earth Data	08/28/85	0.5	steel/pvc	1.5	17.5	42.34	Monitoring	Active
26A	Earth Data	08/28/85	0.5	steel/pvc	1.5	17.5	42.91	Monitoring	Destroyed*
27A	Earth Data	08/28/85	0.5	steel/pvc	1.5	18.5	44.42	Monitoring	Destroyed
28A	Earth Data	08/28/85	0.5	steel/pvc	1.5	17.0	46.73	Monitoring	Destroyed
29A	Earth Data	08/28/85	0.5	steel/pvc	1.5	17.0	UN	Monitoring	Destroyed
30A	Earth Data	10/07/85	0.5	steel/pvc	1.5	20.0	45.88	Monitoring	Active
31A	Earth Data	10/04/85	1.25	steel/steel	10.0	20.5	43.63	Recovery	Active
32AR	Earth Data	10/04/85	2.0	steel/pvc	10.0	20.0	44.70	Monitoring	Active
33A	Earth Data	10/07/85	0.5	steel/pvc	1.5	17.0	44.42	Recovery	Active
34AR	Earth Data	10/23/85	2.0	steel/pvc	10.0	20.0	43.83	Recovery	Active
35AR	Earth Data	10/18/85	2.0	steel/pvc	10.0	18.0	46.63	Recovery	Active
36AR	Earth Data	10/18/85	2.0	steel/pvc	10.0	18.0	46.63	Recovery	Active

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Table 2-4 (Continued)

WELL	DRILLER	DATE INSTALLED	DIAMETER (inches)	MATERIAL (casing/screen)	SCREEN LENGTH (feet)	TOTAL DEPTH (feet)	REFERENCE ELEVATION (ft., NGVD)	FINAL SERVICE	STATUS AS OF 04/90
37A	Earth Data	06/18/85	0.5	steel/pvc	1.5	18.0	44.82	Monitoring	Missing
38A	Earth Data	06/18/85	0.5	steel/pvc	1.5	18.0	44.07	Monitoring	Active
39A	Earth Data	06/18/85	0.5	steel/pvc	1.5	18.0	42.81	Monitoring	Active
40A	Earth Data	06/18/85	0.5	steel/pvc	1.5	18.0	UN	Monitoring	Destroyed
41A	Earth Data	06/18/85	0.5	steel/pvc	1.5	18.0	42.85	Monitoring	Active
42A	Earth Data	06/18/85	0.5	steel/pvc	1.5	18.0	42.90	Monitoring	Active
43AR	Earth Data	06/09/85	4.0	steel/steel	12.0	20.0	48.00	Recovery	Active
44A	Earth Data	06/10/85	4.0	steel/steel	2.0	18.0	45.88	Monitoring	Active
45A	UN	UN	1.0	pvc/pvc	UN	UN	UN	Monitoring	Active
45B	Earth Data	06/10/85	4.0	steel/pvc	10.0	49.0	42.05	Monitoring	Active
46A	UN	UN	UN	UN	UN	UN	UN	Monitoring	Missing
47A	UN	UN	UN	UN	UN	UN	UN	Monitoring	Missing
48A	UN	UN	1.0	pvc/pvc	UN	UN	UN	Monitoring	Active
Simon	UN	UN	UN	UN	UN	UN	UN	Domestic	Active
Lambertson	UN	UN	UN	UN	UN	UN	UN	Domestic	Active
Harmic	UN	UN	UN	UN	UN	UN	UN	Domestic	Active
Phillips	UN	UN	UN	UN	UN	UN	UN	Domestic	Active
Killen	Johns Well	04/83	UN	UN	UN	35.0	UN	Domestic	Active
Gearh-Curley	UN	UN	UN	UN	UN	UN	UN	Domestic	Active
Johnson	Rudy Byler	02/18/72	UN	UN	UN	32.07	UN	Domestic	Active
Durham	Lifetime	1970	UN	UN	UN	80.0	UN	Domestic	Active
Cote	UN	UN	UN	UN	UN	UN	UN	Domestic	Active
Am. Roofing	UN	04/84	UN	UN	UN	40.0	UN	Domestic	Active
Gearhart-Old	UN	UN	UN	UN	UN	UN	UN	Domestic	Destroyed
Gearhart-New	John Fuhr	09/11/85	2.0	pvc/pvc	5.0	50.0	UN	Domestic	Active
Williams	Lifetime	1974?	UN	UN	UN	70.07	UN	Domestic	Active
Gassaway	UN	UN	UN	UN	UN	UN	UN	Domestic	Active
Wokes	UN	UN	UN	UN	UN	UN	UN	Domestic	Active

* Protective casing missing or destroyed; well exists, but can not be sampled.
UN Unknown

Source: Cobe Associates, Inc., March 1987
BCM Engineers Inc. (BCM Project No. 00-01/12-02)

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TABLE 2-5

MONITORING WELL SPECIFICATIONS

CHEM-SOLV, INC. SITE REMEDIAL INVESTIGATION
CHESWOLD, DELAWARE

Well	Total Well Depth (ft., below ground)	Screened Interval (ft., below ground)	Reference Elevation (ft., NGVD)		
			Outer Steel Casing	Inner PVC Casing	Ground Surface
MWI-1-43	43	33 - 43	49.88	49.67	48.20
MWI-2-10	40	30 - 40	43.11	42.61	43.04
MWS-3-17	17	4 - 17	40.17	39.81	40.13
MWI-4-40	40	30 - 40	41.01	40.90	41.01
MWS-5-18	18	5 - 18	40.92	40.37	40.91
MWS-6-25	25	15 - 25	41.41	40.90	41.45
MWS-7-25	25	15 - 25	41.04	40.25	41.08

NGVD National Geodetic Vertical Datum

Source: BCM Engineers Inc. (BCM Project No. 00-6012-02)

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SECTION 3.0

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3.0 ENVIRONMENTAL SETTING

3.1 REGIONAL SETTING

3.1.1 Physiography

The Chem-Solv site is located within the Atlantic Coastal Plain physiographic province, which is characterized as a series of unconsolidated or partially consolidated layers of sand, gravel, silt, and clay. These sediments form a wedge that dips and thickens to the southeast. The thickness of the Coastal Plain sediments is approximately 3,300 feet in the vicinity of the site. This section of sediments consists of the Miocene Calvert Formation of the Chesapeake Group, which is overlaid by the surficial Columbia Formation. Regional geologic information is addressed along with the local geologic setting in Section 3.2.1.

3.1.2 Climate

Long-term climatological data are available from the Dover, Delaware, observation station of the National Oceanic and Atmospheric Administration (NOAA). Monthly summaries of average temperature, precipitation, and wind data from December 1942 through August 1986 are provided in Tables 3-1 through 3-3.

3.1.3 Demographics

The total population of Kent County, Delaware, is 105,200, according to 1980 U.S. Census data. With a land area of 595 square miles, the number of people per square mile averages 176.8. The ratio of males to females in the county in 1984 was 94.7:100. Per capita personal income was \$10,585.00 in 1984.

The total population of Cheswold, Delaware, is 269, according to 1980 U.S. Census data. Based on estimates for the 1990 U.S. Census the total population was 311 in 1990 and is projected to reach 330 by 1995. The ratio of females to males in Cheswold was 90.8:100 for 1980 and is estimated to be 104.5:100 for 1990. The 1980 average household income was \$15,108, and the per capita income was \$5,055. According to the 1990 Census, average household income was \$30,709 in 1990, and is projected to be \$37,696 in 1995.

3.1.4 Land Use

The Chem-Solv site is located in an area zoned for agricultural, commercial, and residential land use. Strip development, consisting of commercial establishments and private residences, is found on both sides of Route 13 in the immediate vicinity of the site (Figure 3-1) AR307513

Immediately south of the site, also on the west side of Route 13, is an abandoned field that was part of a former drive-in theatre. The field extends behind the site to the west. South of this field is a lumber yard.

A one-story block building is located immediately north of the site. This structure was associated with a former truck stop/restaurant/fueling establishment. Three underground storage tanks (USTs) were removed from this property in May 1988 (Appendix A-8). These tanks contained diesel fuel and fuel oil.

An antique furniture/refinishing store is located north of the former truck stop on the southwest corner of the intersection of Routes 13 and 42. A church and cemetery are adjacent to the furniture store to the west.

Across from the church, on the north side of Route 42, is a gasoline station/convenience store. DNREC files show that 3 USTs were replaced in June 1990 (Appendix A-8). A vacant lot, formerly the site of a used-car business, is located next to the convenience store on the northwest corner of the intersection of Routes 13 and 42. Analytical data show that soils at this location contain total petroleum hydrocarbons, benzene, toluene, xylene, and ethylbenzene.

An abandoned gasoline station is located on the northeastern corner of the intersection of Routes 13 and 42. A furniture store is located on the southeastern corner of this intersection; however, DNREC UST files indicated that a gasoline station was formerly located there. Three 4,000-gallon USTs were removed in April 1987. At the time of removal, these tanks were cracked (Appendix A-8).

Both sides of Route 42 proceeding east from Route 13 contain private homes, except for the cases described above. A roofing business, a residential home, and a used truck business are all located across Route 13 from the site (proceeding south along Route 13 from the furniture store).

A Pennsylvania railroad line is located approximately 3,000 feet west of the Chem-Solv site. The rail line runs north-south.

3.2 SITE SETTING

3.2.1 Geology

The Chem-Solv site is located within the Coastal Plain Physiographic Province, which is characterized as a series of unconsolidated or partially consolidated layers of sand, gravel, silt, and clay. These sediments form a wedge that dips and thickens to the southeast. The thickness of the Coastal Plain sediments is approximately 3,300 feet in

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the vicinity of the site. This section of sediments consists of the Miocene Calvert Formation of the Chesapeake Group overlaid by the surficial Pleistocene Columbia Formation. Figure 3-2 shows a general profile of the geologic section under the site.

Local geologic conditions are summarized in the following sections. Available DNREC monitoring well logs are provided in Appendix O. Logs for the wells and borings installed for this remedial investigation are provided in Appendices E and F.

3.2.1.1 Soils

The Columbia Formation, a nonmarine fluvial deposit, outcrops at the Chem-Solv site. This formation is locally characterized by unconsolidated, moderately to poorly sorted, coarse-to-fine, brown-to-orange quartz sand. Thin clay, silt, and gravel interbeds are common within the formation.

The surficial sediments of the Columbia Formation are immediately overlaid by the Miocene-age sediments of the Chesapeake Group. These sediments are characterized by gray to bluish-gray silts that are commonly fossiliferous and sometimes sandy. This wedge of sediments begins just south of Middletown, Delaware, and reaches a maximum thickness of 1,550 feet at Fenwick Island (Sundstrom and Pickett, 1968). The nature of these sediments suggests that they were deposited through a series of marine transgressive and regressive sequences.

The soil types in the vicinity of the site have been detailed by the United States Department of Agriculture - Soil Conservation Service (USDA-SCS) in cooperation with the Delaware Agricultural Experiment Station (USDA-SCS, 1971). Figure 3-3 provides a map detailing soil types for the site and surrounding areas. Soil at the site is classified as Sassafras sandy loam: 0 to 2 percent slopes (SaA) and 2 to 5 percent slopes (SaB). The Sassafras consists of deep, well-drained, friable, moderately coarse textured sandy soils. The hazard of erosion is slight in SaA and slightly higher in SaB because of the small slope. The pH of these soils is in the range of 4 to 5.5. The soils retain moisture moderately well and are easy to work. They are good soils for farm and nonfarm uses.

The region surrounding the site consists predominantly of the Sassafras series and of the Fallingston loam (Fs) of the Fallingston series. The Fallingston series consists of medium-textured soils on upland, mainly woodland areas. The soils are poorly to very poorly drained with a moderately permeable to moderately slowly permeable subsoil. Other minor soils occur mostly as small spots within this Sassafras - Fallingston soil region but do not appreciably affect the physical properties or use of the region.

3.2.1.2 Stratigraphy

The Columbia Formation ranges in thickness from 20 to 40 feet in the vicinity of the site. Wells and borings at the site have encountered a silt layer (approximately 1 to 6 feet thick) at approximately 18 to 23 feet below grade (Figure 3-4). This layer separates the upper and lower portions of the aquifer.

The silt layer extends offsite on the eastern side of Route 13 (Figure 3-5). The silt layer was encountered in boring CSB-4, located on the Lambertson property but was not found in boring CSB-5, located on the Route 13 median. A second silt layer was encountered at shallower depths (approximately 14 feet below grade) at borings CSB-2 and CSB-3 and well MHS-6-25. This layer is not laterally contiguous with the silt layer encountered beneath the Chem-Solv site.

3.2.2 Hydrogeology

The average depth to groundwater is approximately 8 feet below ground surface at the site. Because of its limited saturated thickness, only domestic well water needs can be met from this aquifer. However, the aquifer is a source of recharge for deeper artesian aquifers and provides baseflow to local streams. The Columbia Formation is a source of recharge for deeper artesian aquifer between the Columbia Formation and the underlying Cheswold aquifer of the Chesapeake Group (Sundstrom and Pickett, 1968).

Groundwater level measurements were obtained on March 27 and April 4, 1990, and February 19 and April 5, 1991. Water level measurements and the resulting groundwater elevations are provided in Table 3-4. Potentiometric surface contour maps of the water-table (shallow-zone) aquifer are provided as Figures 3-6 through 3-9. Potentiometric surface contour maps for the intermediate-zone aquifer are provided as Figures 3-10 through 3-13.

Water levels in the intermediate zone are slightly deeper under nonpumping conditions than levels in the shallow zone. A difference in head of between 0.59 and 0.70 foot was commonly observed.

Calculated water table gradients of the shallow zone varied from 0.0014 to 0.0035 in previous investigations (CABE, 1987); those gradients ranged from 0.013 to 0.0017 in March and April 1990. Groundwater flow direction is roughly north to northeast; however, groundwater movement in the intermediate zone is roughly parallel to that in the shallow zone (in a northeast direction). Previously calculated horizontal gradients of the piezometric surface of the intermediate zone varied between 0.00025 and 0.0009 (CABE, 1987); gradients in the intermediate zone varied between 0.0025 and 0.00091 in March and April 1990.

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CABE conducted pumping tests in six wells to determine the hydraulic properties of the shallow zone. CABE calculated transmissivity values, which ranged from 1,429 gallons per day per foot (gpd/ft) to 11,330 gpd/ft. Calculated storage coefficients ranged from 0.008 to 0.159. Using a transmissivity of 2,200 gpd/ft and a value of 9.5 feet for the average saturated thickness of the shallow zone, the average hydraulic conductivity (K) is calculated to be 232 gpd/ft² or 31 ft/day.

Groundwater flow velocities in the shallow zone were calculated using an average hydraulic conductivity of 31 ft/day (K) and an average porosity of 0.15. For the March and April 1990 data, a horizontal gradient between 0.013 and 0.0017 produces flow velocities ranging from 0.35 to 2.7 ft/day.

CABE conducted one pumping test in a well finished in the intermediate-flow zone (OB-45B). The well was pumped for 1 hour at a rate of 21.4 gpm on June 18, 1986. A transmissivity value of 31,386 gpd/ft and a storativity value of 1.45×10^{-5} were calculated from the test data. Because the thickness of the intermediate zone is not known, CABE could not directly calculate a hydraulic conductivity (K) for the zone from the transmissivity value. Therefore, flow velocities cannot be calculated.

3.2.3 Surface Features

The principal regional surface water features include the Leipsic River, Garrisons Lake, Masseys Millpond, the Fork Branch of the St. Jones River, and Silver Lake (Figure 3-14). The Leipsic River, which runs approximately east-west, is located 1.3 miles north of the site; the Alston Branch runs north-south, approximately 0.4 mile from the site. Masseys Millpond and Garrisons Lake, which are located along the Leipsic River, are situated approximately 2.5 miles and 1.5 miles northwest of the site. Silver Lake, which is located along the St. Jones River, is located 3.2 miles southeast of the site. The St. Jones River runs approximately north-south along the eastern edge of Dover, Delaware.

The water shed areas are delineated in Figure 3-15. BCM determined the boundaries according to the surface topography. The site is located within a water shed with a total area of approximately 5.3 million square feet, or 122 acres. Surface drainage from the site is directed to the north, to the Alston Branch of the Leipsic. Since the site appears to lie close to a water shed boundary, some surface water may also migrate to the east to the adjacent, unnamed branch of the Leipsic River.

The site is generally well vegetated. A description of vegetation types is provided in Section 5.6.3. Although the site is not located in a wetlands area, such an area lies 1 to 1 1/2 miles north of the site surrounding the Leipsic River and some of its tributaries (Figure 3-16). The area is classified as zone V: Transition Marsh, according to the Wetlands Classification System, which is based on associated flora

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(Delaware State Planning Office, 1976). No single plant species dominates this zone, which contains ample species of vegetation that grow under physiographic conditions of wet, muddy areas of low salinity, still affected by tidal action. Associated waterfowl and wildlife thrive thanks to ample conditions for food, nesting, and shelter. Just beyond the northeast corner of Figure 3-16, also along the river, zone V gives way to zone I. This zone is a marsh or wetland in which 50 percent of the area is salt marsh cordgrass. This primary species thrives in the saline to brackish water found here, on a layer of peat formed from roots and accumulated muddy sediment. Secondary flora is usually associated with spoil banks along drainage ditches and portions of the marsh above mean high water. This area is also a major refuge for ducks, geese, muskrats, and other wildlife.

The site is not located within the 100-year floodplain (U.S. Department of Housing and Urban Development, 1975). The 100-year flood boundaries are indicated on Figure 3-17. They include the Leipsic River and portions of its tributaries, notably the Alston Branch, which is located approximately 1/2 mile northwest of the site. Farther from the site, a little over a mile to the east, the 100-year flood boundary surrounds the Dyke Branch of the Leipsic River, and at about the same distance to the south, it encompasses the Fork Branch of the St. Jones River.

Site topography is fairly flat (Figure 3-18). A surface depression runs east-west along the southern site boundary; this depression resulted from the excavation and processing of 1,300 cy of soil during site soil remediation activities in 1985. Because this soil has been mechanically reworked, it has different physical characteristics from the surrounding undisturbed soil. As a result, surface water tends to collect in this depression after rain.

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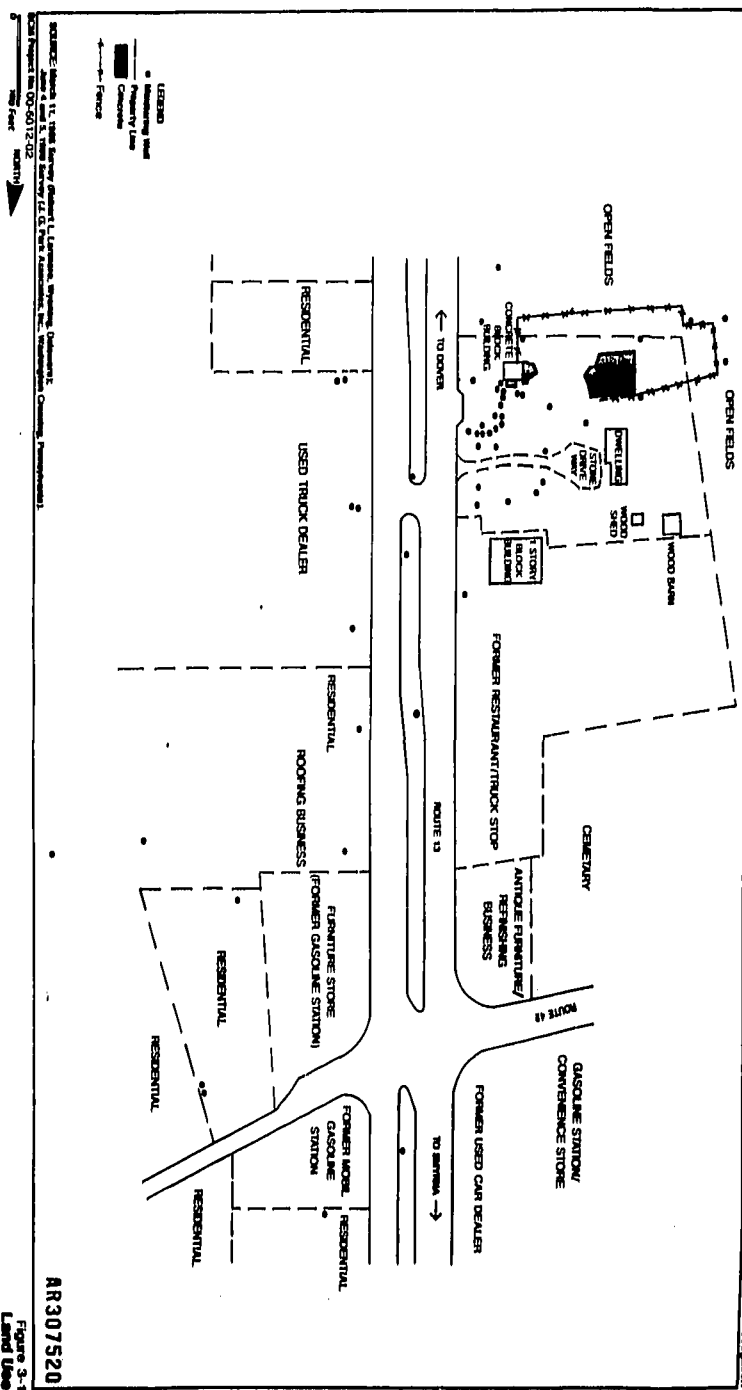
SECTION 3.0
FIGURES

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CHESAPEAKE, INC. SITE
Environmental Investigation



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BCHB Project No. 03-6012-02

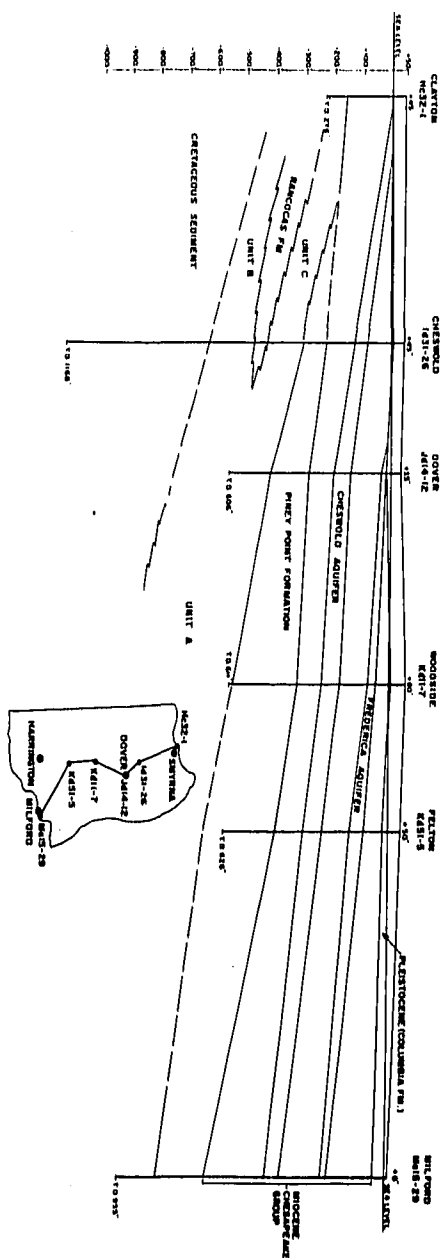


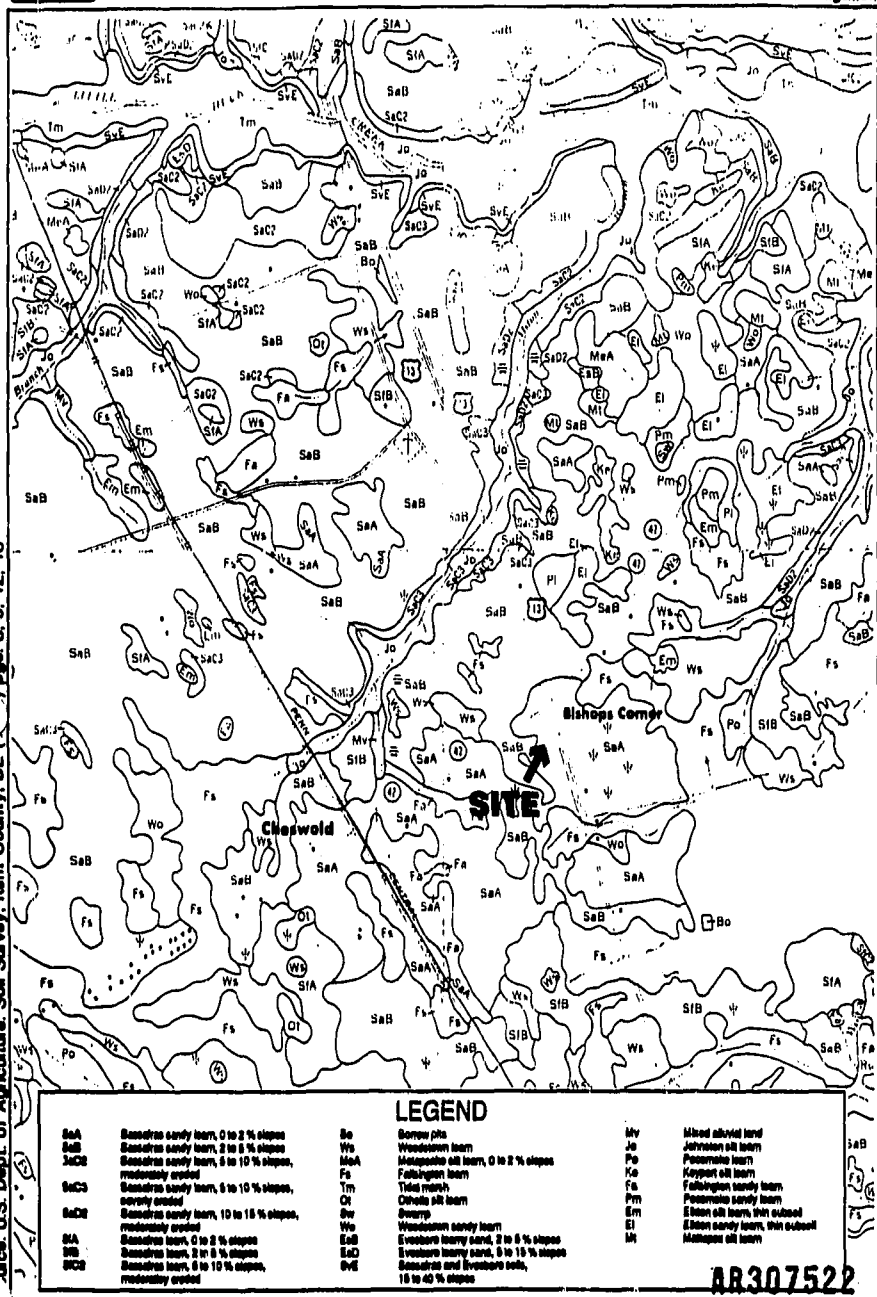
Figure 3-2
Geologic Cross Section of Kent County

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CHEM-SOLV, INC. SITE
Remedial Investigation

Source: U.S. Dept. of Agriculture, Soil Survey, Kent County, DE, pgs. 8, 9, 12, 13



BCM Project No. 00-8012-02

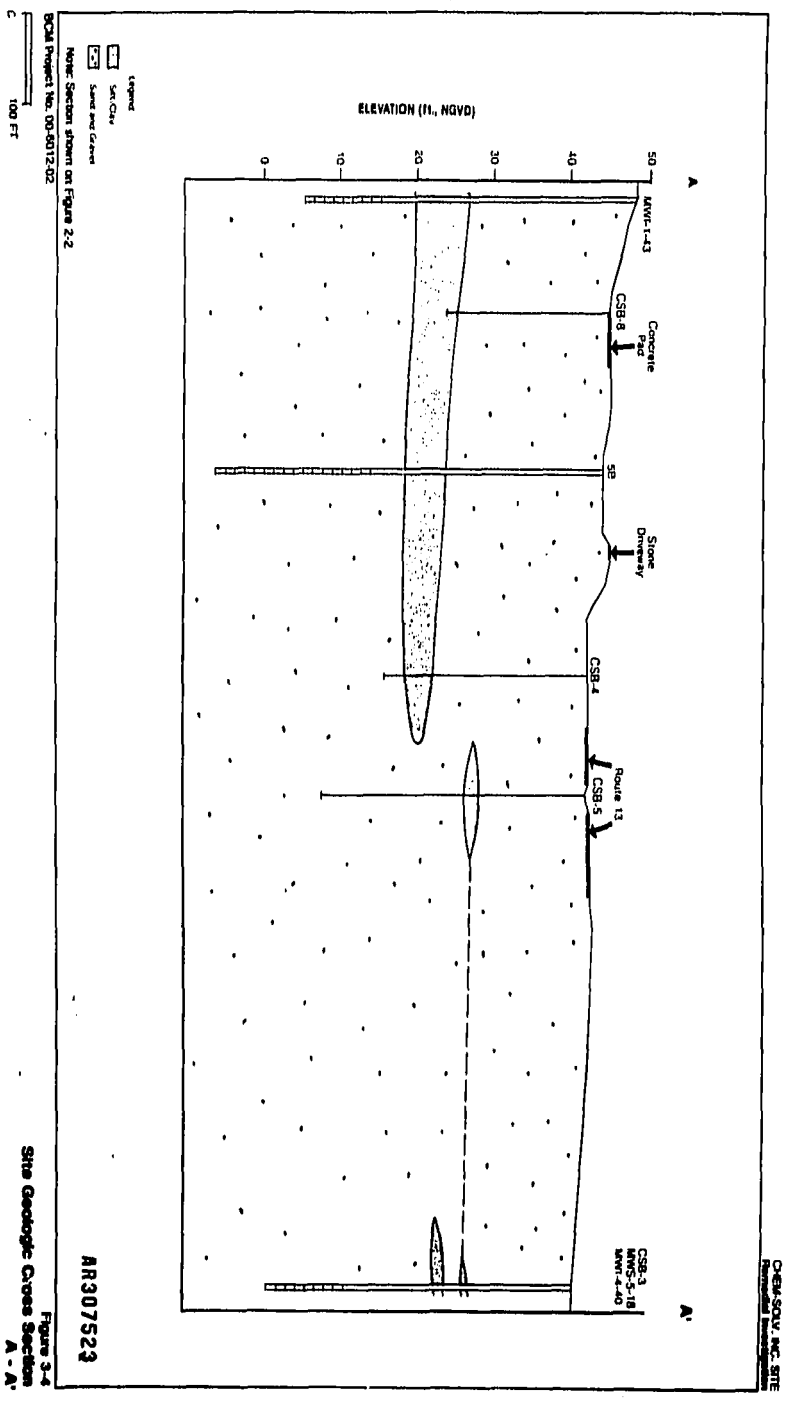
0 1/4 MILE

NORTH

AR307522

Figure 3-3
Soils Map

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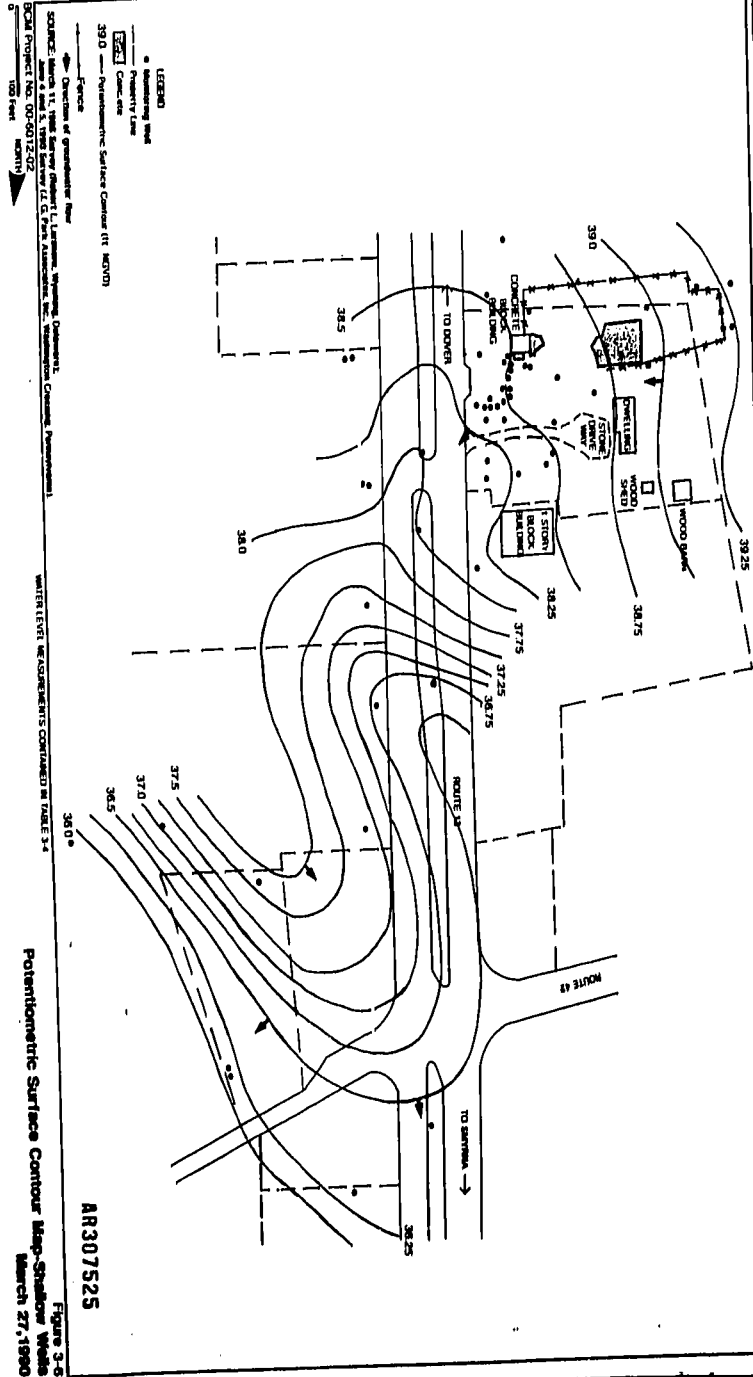
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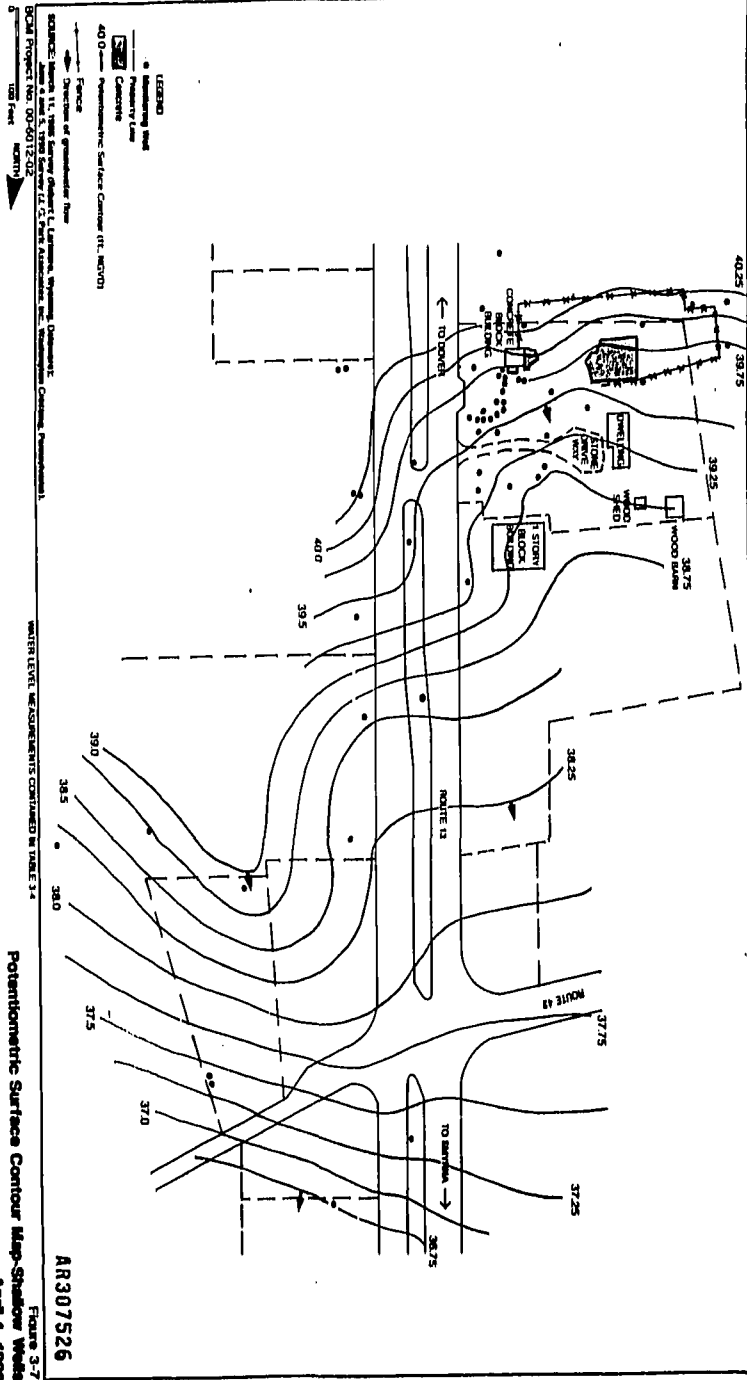
CHESAQUA, INC. SITE
POTENTIALITY STUDY



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BM1

CREAGOV INC. SITE
Remedial Investigation



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CHESAIRE, INC. SITE

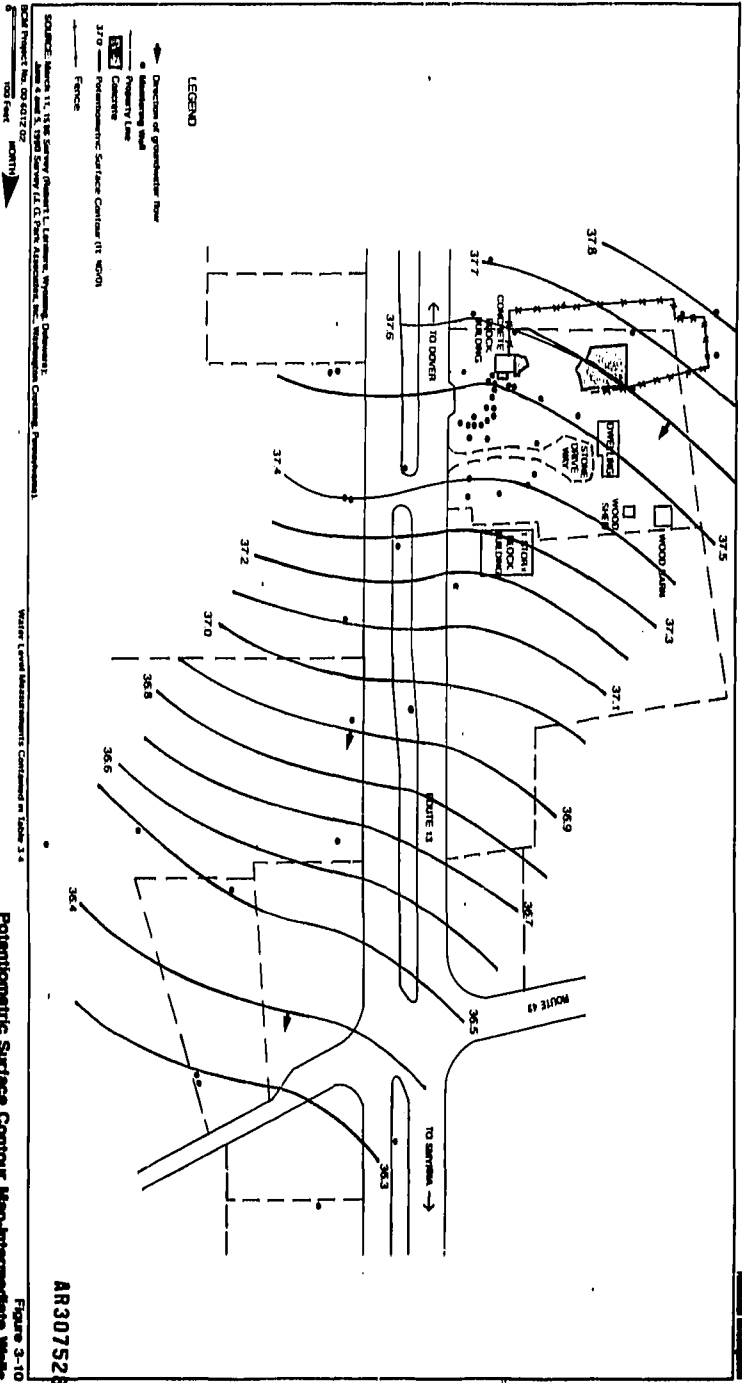
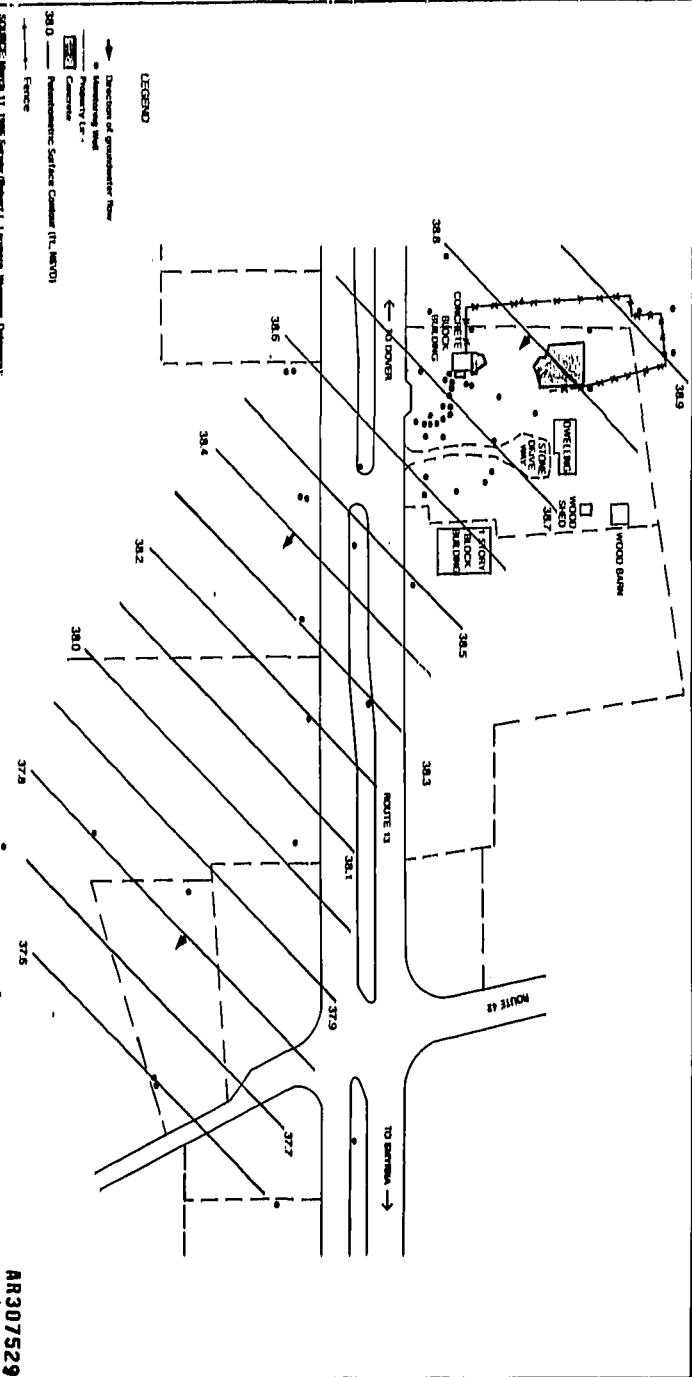


Figure 3-10
Potentiometric Surface Contour Map-Intermediate Wells
March 27, 1980

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CHESAUTUK INC. SITE
INTERIOR PHOTOGRAPH



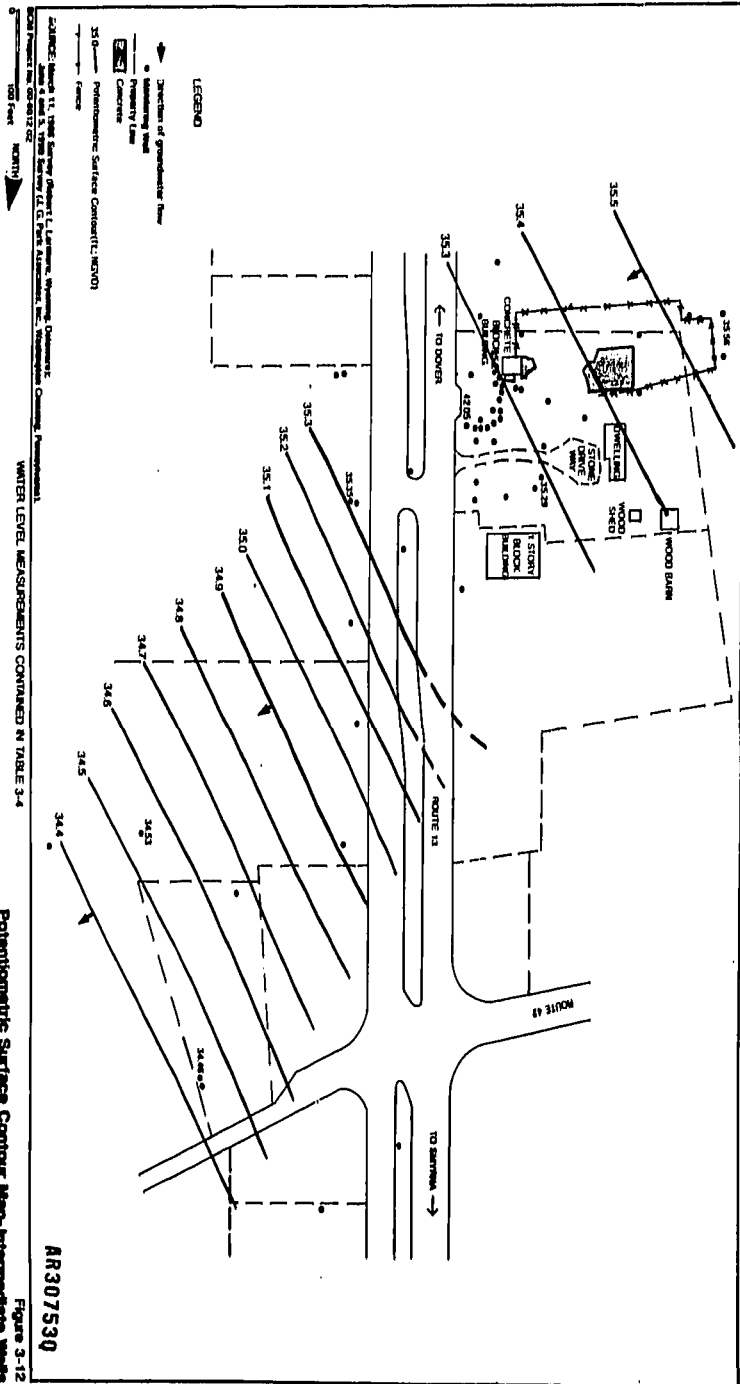
SOURCE: March 11, 1986 Survey District 1, Lancaster, Wyoming, Chesautuk Inc.
June 4 and 5, 1980 Survey 12 G. Davis Associates, Inc., Washington, Colorado, Pennsylvania

WATER LEVEL MEASUREMENTS CONTAINED IN TABLE 3-4

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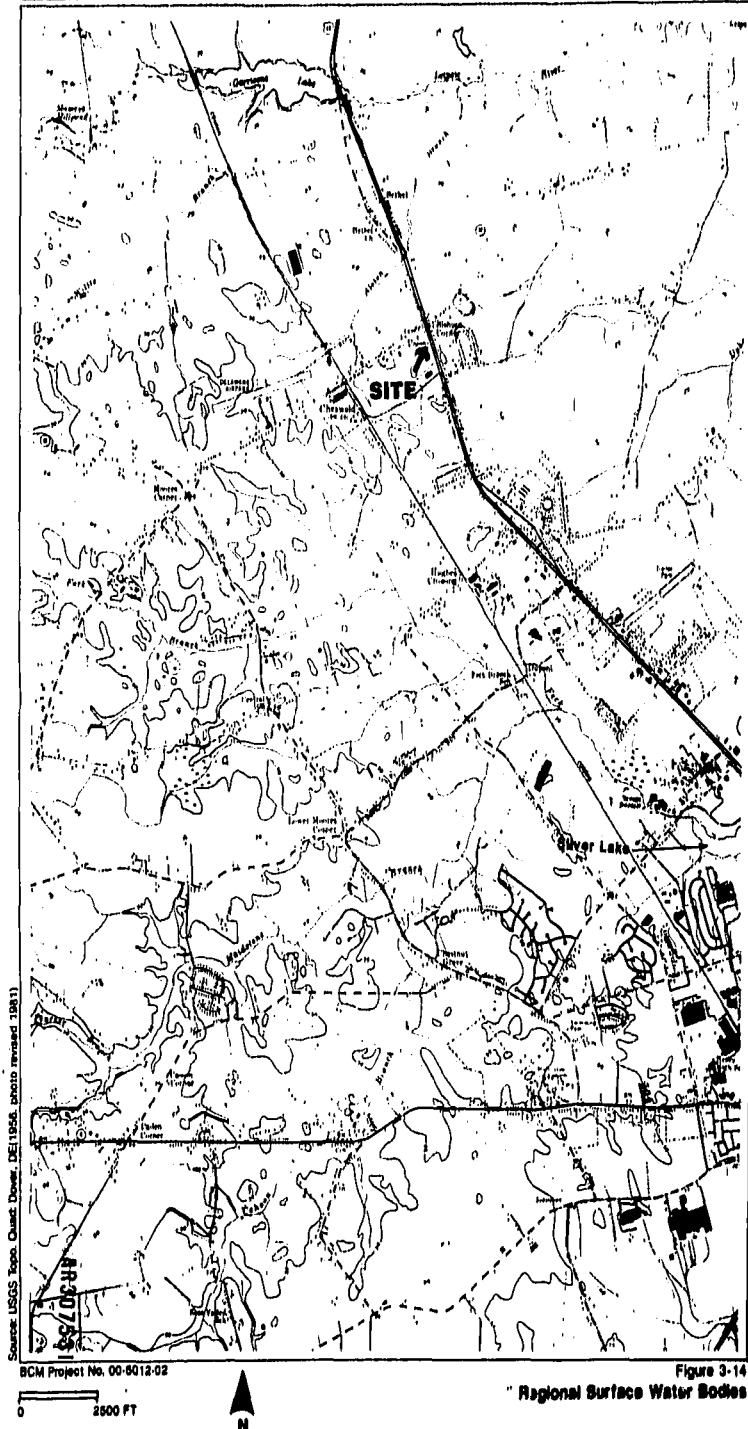
Figure 3-11
Potentiometric Surface Contour Map - Intermediate Wells
April 4, 1980

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Potentiometric Surface Contour Map-Intermediate Wells
Figure 3-12
February 19, 1991

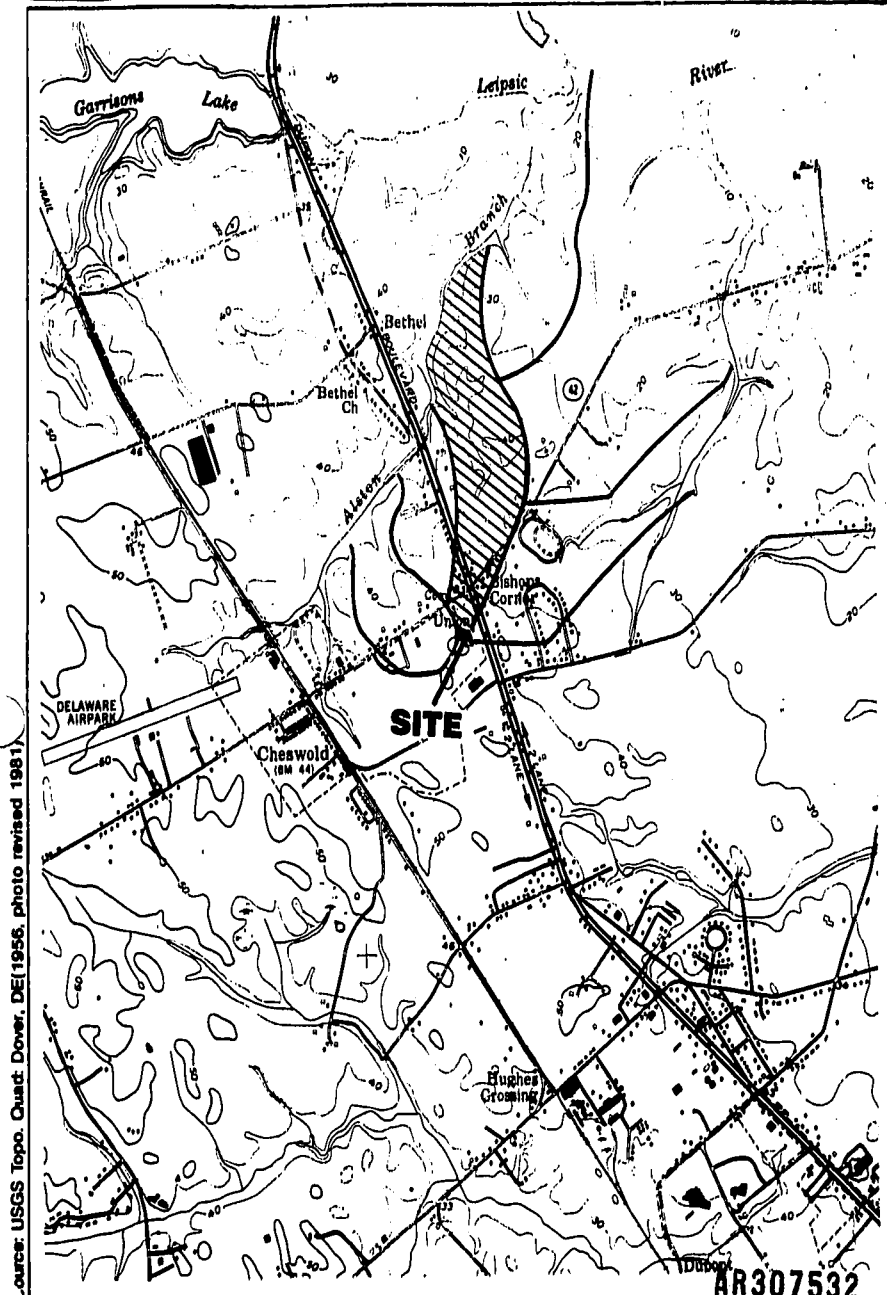
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CHEM-SOLV, INC. SITE
Remedial Investigation



Source: USGS Topo. Quad: Dover, DE (1956, photo revised 1981)

BCM Project No. 00-0012-02

LEGEND

Water Shed Boundary

Site Water Shed

0 2000 FT

NORTH

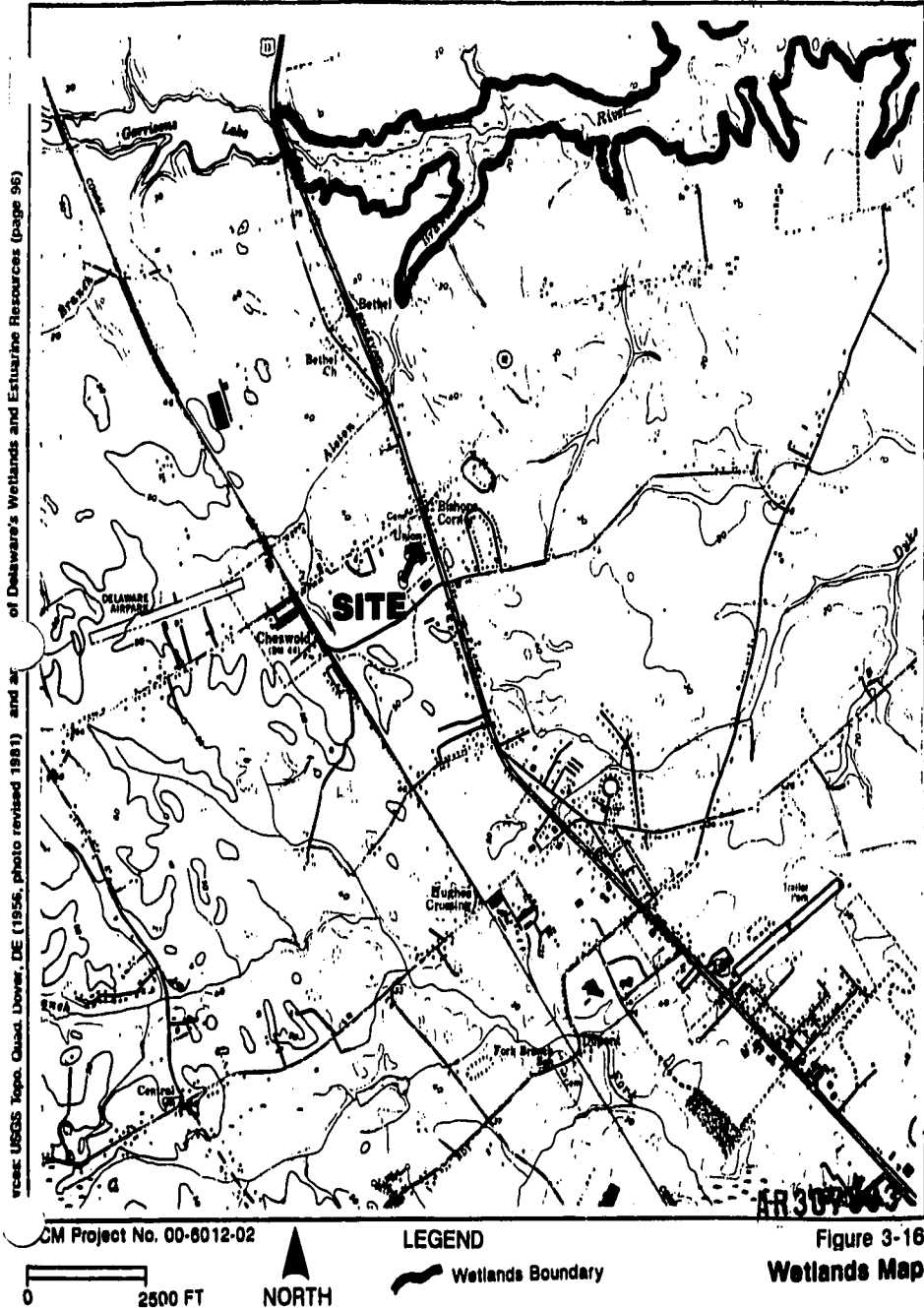
Delineation of Water Shed Areas

Figure 3-15

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CHEM-SOLV. INC. SITE
Remedial Investigation



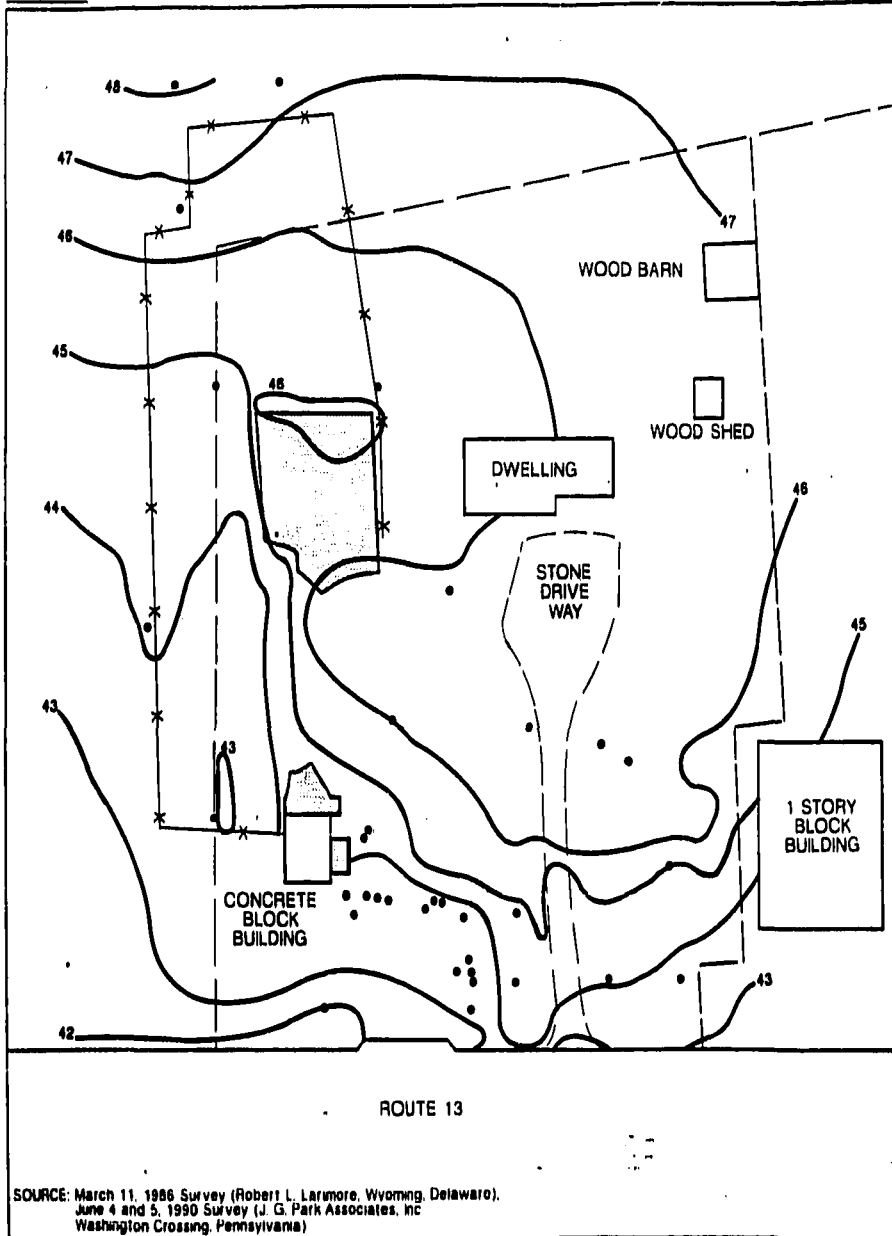
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CHEM-SOLV. INC. SITE
Remedial Investigation



SOURCE: March 11, 1986 Survey (Robert L. Larmore, Wyoming, Delaware).
June 4 and 5, 1990 Survey (J. G. Park Associates, Inc.
Washington Crossing, Pennsylvania)

BCM Project No. 00-6012-02

LEGEND

● Monitoring Well

— Property Line

Concrete

42 — Topographic Contour (Elevation in feet, NGVD)

— Fence

NORTH

0 50 Feet

AR307595 3-18
Site Topography

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SECTION 3.0
TABLES

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TABLE 3-1
AVERAGE MONTHLY TEMPERATURE DATA
DOVER AIR FORCE BASE
CHEM-SOLV, INC. SITE REMEDIAL INVESTIGATION
CHESHOLD, DELAWARE

Month	Average Temperature (°F)*
January	33
February	36
March	43
April	53
May	63
June	72
July	76
August	75
September	68
October	58
November	47
December	37

* Monthly averages compiled from December 1942 through August 1986.

Source: U.S. Department of Commerce
National Oceanic and Atmospheric Administration

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TABLE 3-2
AVERAGE MONTHLY PRECIPITATION DATA
DOVER AIR FORCE BASE
CHEM-SOLV, INC. SITE REMEDIAL INVESTIGATION
CHESWOLD, DELAWARE

Month	Average Precipitation (Inches)*
January	3.0
February	3.0
March	3.9
April	3.2
May	3.4
June	3.2
July	4.3
August	4.4
September	3.5
October	3.0
November	3.5
December	3.5

* Monthly averages compiled from December 1942 through August 1986.

Source: U.S. Department of Commerce
National Oceanic and Atmospheric Administration

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TABLE 3-3
AVERAGE MONTHLY WIND DATA
DOVER AIR FORCE BASE
CHEM-SOLV, INC. SITE REMEDIAL INVESTIGATION
CHESHOLD, DELAWARE

Month	Prevailing Direction*	Average Speed (mph)*
January	WNW	8
February	NW	7
March	NW	8
April	WNW	7
May	SSW	6
June	SSW	5
July	SSW	5
August	SSW	5
September	N	5
October	N	6
November	N	7
December	WNW	7

* Monthly averages compiled from December 1942 through August 1986.
mph - Miles per hour

Source: U.S. Department of Commerce
National Oceanic and Atmospheric Administration

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TABLE 3-4

WATER LEVEL MEASUREMENTS

CHEM-SOLV, INC. SITE REMEDIAL INVESTIGATION
CHESWOLD, DELAWARE

WELL	Reference Elevation (ft., NGVD)	Depth to Water (ft. below ground surface)				Groundwater Elevation (ft., NGVD)			
		03/27/90	04/04/90	02/19/91	04/03/91	03/27/90	04/04/90	02/19/91	04/03/91
2A	46.00	7.48	5.94	10.17	8.21	38.52	40.36	35.83	37.79
3A	46.88	7.58	6.96	10.54	8.83	39.00	39.90	36.34	38.05
4A	47.49	8.57	7.63	11.23	9.55	38.82	39.86	36.26	37.94
5A	48.42	7.04	5.82	9.83	7.81	38.38	38.80	35.79	37.81
5AR	44.86	0.32	0.06	(1)	(1)	38.53	38.80	(1)	(1)
5B	43.63	8.11	6.90	10.37	8.49	37.52	38.73	35.26	37.14
6B	46.37	(2)	7.33	(1)	8.92	(2)	38.82	(1)	37.33
8A	42.30	4.09	2.01	6.67	4.68	38.21	40.29	35.83	37.82
8B	42.30	4.90	3.86	5.95	5.31	37.40	38.44	35.35	36.90
9A	46.24	7.95	7.22	10.46	8.64	38.29	39.02	35.78	37.00
9B	46.00	8.57	7.32	10.71	8.85	37.43	38.88	35.29	37.19
10A	43.46	5.90	3.79	7.87	5.00	37.56	38.87	35.79	37.77
11A	43.45	5.02	3.51	(3)	(3)	38.43	39.84	(3)	(3)
12A	43.32	(4)	(4)	(4)	(4)	(4)	(4)	(4)	(4)
13A	45.43	6.58	5.04	8.21	7.22	38.84	40.36	36.22	38.81
14A	44.28	5.80	3.98	6.36	6.30	38.48	40.80	35.88	37.88
15A	45.88	7.21	6.13	9.75	7.86	38.38	39.46	35.84	37.73
16A	43.63	5.65	4.45	8.12	6.22	38.18	39.28	35.71	37.81
17A	45.24	6.98	6.14	9.41	7.63	38.28	38.10	35.83	37.81
18A	47.26	8.50	(5)	(5)	(5)	38.78	(5)	(5)	(5)
18A	46.88	8.02	7.24	10.82	8.73	38.86	38.44	36.06	37.96
20AR	43.97	(6)	(6)	(6)	(1)	(6)	(6)	(6)	(1)
22A	46.11	8.67	8.38	11.53	9.87	39.24	39.72	36.58	38.24
24A	42.47	4.40	2.86	7.01	4.86	38.07	38.81	35.48	37.81
25A	42.88	4.80	3.18	(4)	(4)	38.08	38.53	(4)	(4)
26A	42.34	4.11	3.03	8.87	4.73	38.23	38.31	35.87	37.81
27A	42.81	(4)	(4)	(4)	(4)	(4)	(4)	(4)	(4)
31A	45.88	7.01	4.88	-	6.48	38.87	40.88	-	38.23
32AR	43.83	5.19	3.86	(6)	(1)	38.34	38.87	(6)	(1)
33A	43.70	5.34	4.14	7.97	6.06	38.36	38.88	35.73	37.84
34A/1	44.42	5.80	(6)	(6)	(1)	38.52	(6)	(6)	(1)
36AR	43.63	5.34	(1)	7.80	(1)	38.28	(1)	35.73	(1)
36AR	45.83	7.52	6.19	(6)	(1)	38.31	38.84	(6)	(1)
38A	44.07	8.18	8.91	-	10.11	35.91	37.15	-	33.98
38A	42.81	5.91	4.03	8.82	5.19	38.70	38.88	35.79	37.42
41A	42.88	5.48	4.47	7.33	5.78	37.37	38.38	35.80	37.08
42A	42.80	5.27	4.00	7.34	5.46	37.63	38.80	35.86	37.44
43AR	46.00	7.81	6.28	10.23	(1)	38.38	38.72	38.77	(1)
44A	46.88	7.67	6.40	10.25	8.19	38.21	38.38	35.83	37.88
45A	(7)	8.62	6.88	10.86	8.71	(7)	(7)	(7)	(7)
45B	42.08	-	5.84	8.21	7.38	-	38.21	32.84	34.87
48A	(7)	9.24	7.67	11.38	9.38	(7)	(7)	(7)	(7)
MHW-1-43	46.87	11.88	10.87	14.11	12.24	37.81	38.00	35.98	37.43
MHW-2-40	42.81	8.11	4.82	8.08	6.28	38.80	37.79	34.53	36.33
MHW-4-40	40.80	4.80	3.30	8.44	4.88	38.30	37.80	34.46	36.21
MHW-3-17	38.81	3.77	1.58	5.00	3.23	38.04	38.22	34.81	36.88
MHW-6-18	40.37	4.27	3.00	5.88	4.13	38.10	37.37	34.71	36.24
MHW-8-28	40.80	4.88	4.18	8.87	4.74	38.34	38.74	34.23	36.18
MHW-7-25	40.25	3.81	2.86	5.50	4.84	38.44	37.38	34.75	35.71

(1) Could not unlock box to access well head

(2) Well 6B was not located until April 4, 1990

(3) Well 11A found February 19, 1991, with outer casing uprooted and inner casing bent

(4) Well destroyed or missing

(5) Well 18A found April 4, 1990, with outer casing uprooted and inner casing bent

(6) Could not get probe of electric water level recorder down well casing

(7) No reference elevation available

NGVD: National Geodetic Vertical Datum

Source: BCM Engineers Inc. (BCM Project No. 00-8012-02) and Cobe Associates (March 1987)

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SECTION 4.0

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4.0 NATURE AND EXTENT OF CONTAMINATION

4.1 AIR CHARACTERIZATION

BCM conducted an air investigation on October 16, 1989, to evaluate the health and safety needs at the site before initiating sampling or intrusive activities. Organic vapor readings from 12 locations positioned around the perimeter of the site were obtained using both an HNu and an OVA. During the sampling, the wind was moving from the south/southwest direction. Results are presented in Table 4-1.

No sustained organic vapor readings above background levels were measured using the HNu. Organic vapor measurements ranging from 0.4 to 1.9 units were recorded using the OVA.

4.2 SOURCE CHARACTERIZATION

4.2.1 DNREC Investigation Results

In previous investigations, DNREC analyzed soils in the vicinity of the former distillation building. Approximately 1,300 cy of soil were excavated, treated, analyzed, and placed back into the excavation.

As mentioned in Section 1.2.1, SMC Martin conducted two phases of soil sampling at the Chem-Solv facility. Although a soil sample was apparently collected shortly after the September 1984 fire (CABE, 1987), no data on this sample were available. All soil sampling discussed below took place after the 1,300 cy of contaminated soil had been excavated (Appendix G).

The first phase of soil sampling occurred before the initiation of the soil shredding/aeration remedial process in May and August 1985. Sampling during phase one was designed to determine:

1. The extent and amount of contamination existing in the soil that had not been excavated either in the resultant pit or nearby in-place soil
2. The specific range of concentrations and type of compounds present in the excavated (stockpiled) soils

The second phase of soil sampling occurred during the shredding/aeration operation in September and November 1985. Phase Two sampling was used to determine whether the shredding/aeration process was reducing the amount of volatile organic compound (VOC) contamination in the excavated soil.

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4.2.1.1 Phase One Soil Sampling

On May 1, 1985, SMC Martin collected 11 Phase One soil samples. Six were grab-sampled from 6 inches into the excavation sidewall, two were grab-sampled from 6 inches into the floor of the excavation, and three each were composite-sampled from separate 3-foot borings into the stockpiled soil. For details of sampling methods, refer to the 1986 SMC Martin report.

The 11 samples were analyzed for the following VOCs:

- trichloroethylene (trichloroethene or TCE)
- 1,1,1-trichloroethane
- tetrachloroethylene (tetrachloroethene or PCE)
- chloroform
- toluene
- xylene

Chloroform, toluene, and xylene were not detected in any of the May 1, 1985, samples.

Total VOC concentrations in three of six sidewall samples were 40 micrograms per kilogram (ug/kg), 41 ug/kg, and 120 ug/kg. In the other three sidewall samples, none of the above VOCs were detected. In the floor samples, total VOC levels were 132 ug/kg and 3,640 ug/kg; in the stockpiled soil samples, the total VOC concentrations were 131 ug/kg, 244 ug/kg, and 26 ug/kg.

Four Phase One soil samples were collected on May 10, 1985. Two samples were obtained from 0- to 3-foot intervals bored into the stockpiled soil. One sample was collected from a boring at a depth of 0.5 to 3 feet in a nearby drainage way. The fourth sample was taken from a 6-inch boring into the floor of the excavated pit. These samples were analyzed for TCE, PCE, 1,1,1-trichloroethene (1,1,1-TCA), and chloroform, even though chloroform and PCE were not detected in the May 1, 1985, samples.

Total VOC concentrations in the stockpiled soil samples were 41 ug/kg and 93 ug/kg, while that in the excavation floor sample was 282 ug/kg. The sample collected from the drainage way contained none of the above VOCs.

On August 16, 1985, the last Phase One samples were collected. Thirteen samples were composited from 0- to 3-foot intervals bored into the in-place soils adjacent to the stockpiled soils. Six of these samples were analyzed for VOCs, and seven were analyzed for certain VOCs and acid/base neutral organic compounds.

No acid/base neutral organic compounds were detected in any of the above samples. Two samples contained VOCs with total concentrations of 31 ug/kg and 1.9 ug/kg.

Twenty-four samples were also collected from the soil stockpiles on August 16, 1985. These samples were composited from 3- to 4-foot intervals in boreholes up to 9 feet deep and were analyzed for VOCs. Fourteen samples had VOCs detected, with total concentrations ranging from 1.1 ug/kg to 480 ug/kg.

From the above discussion, it is clear that some VOC-contaminated soil had been left in the area where the 1,300 cy of soil was excavated. The excavation did not extend laterally far enough nor deep enough, although the soil was apparently removed to the water table. In addition, the in-place soil in the vicinity of the stockpiled soils appeared to have some minor VOC contamination. The stockpiled soils contained significant levels of VOCs before soil shredding/aeration. A summary of the Phase Two sampling to determine the VOC removal efficiency of the remedial process is contained in the following section.

4.2.1.2 Phase Two Soil Sampling

During the soil shredding/aeration process, soil samples were collected before and after passage through the system to evaluate VOC removal across the shredder. To facilitate easier handling of the material, the entire soil stockpile was divided into eleven lots. A total of 122 samples were collected as each of the eleven lots was passed through the shredder.

4.2.2 Remedial Investigation Results

During the RI investigation, samples of unsaturated soils from locations around the edge of the former excavation were analyzed for TCL organic and TAL inorganic parameters. Results of these soil samples were used to determine whether the undisturbed soils adjacent to the excavation contained volatile contaminants associated with the site. In addition, previous sampling by DNREC concentrated on characterization of volatile organic compounds. Results of the additional organic and inorganic analyses were used to characterize these compounds.

Sixteen soil samples, including two field duplicate samples, were retained from unsaturated soils at seven boring locations and submitted to the IEA laboratory for TCL organic and TAL inorganic analyses. These samples were obtained in December 1989 and February 1990. Seven additional soil samples, obtained from the saturated interval just above the silt layer, were analyzed for TCL volatile organic analyses. A summary of the analytical results is presented in Table 4-2. The distribution of organic compounds detected onsite is shown on Figure 4-1. Analytical results (without accompanying documentation) are contained in Appendix H. The data validation report for these samples is also provided in Appendix H.

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Four split samples from three locations were retained for EPA by FPC personnel for chemical analyses. A summary of these data is presented in Table 4-3. The EPA data validation reports, which contain the analytical data and documentation, are contained in Appendix I. An evaluation of the comparability of these data sets is also contained in Appendix I.

4.2.2.1 Volatile Organic Compounds

Four volatile organic compounds -- acetone, chloroform, methylene chloride, and TCE -- were detected in onsite soils. However, the presence of acetone in the soils cannot be positively attributed to the samples, because of contamination of the associated laboratory and lot field blanks with this compound. In addition, the presence of methylene chloride cannot be positively attributed to 11 of the 12 samples it was detected in, because of the presence of the compound in the associated blanks; however, methylene chloride was detected in the sample from 2 to 4 feet for boring CSB-9 at 4 micrograms per kilogram (ug/kg). The distribution and concentration of chloroform, methylene chloride, and TCE are shown on Figure 4-1.

Chloroform was detected in three samples, CSB-6 (6-7.3), CSB-7 (8-10), and CSB-7 (20.5-20.8), at concentrations ranging from 4 ug/kg to 8 ug/kg. TCE was detected in two surface samples, CSB-8 (0.5-2) and CSB-11D (0.5-2), at levels of 5 ug/kg and 6 ug/kg, respectively. TCE was not detected in the CSB-11 (0.5-2) duplicate sample; however, the detected concentration of TCE was at the quantitation limit for that compound and does not indicate a discrepancy for the data set.

One soil sample from among those collected in December 1989 contained two volatile organic tentatively identified compound (TIC) and at an estimated concentration of 10.0 ug/kg each. This sample was obtained from the 0.5- to 2-foot interval of Boring CSB-12.

4.2.2.2 Semivolatile Organic Compounds

Three semivolatile organic compounds, benzoic acid, bis (2-ethylhexyl) phthalate, and isophrone, were detected in the soil samples. Benzoic acid was detected in one surface sample, CSB-12 (0.5-2), at 580 ug/kg. Bis (2-ethylhexyl) phthalate was found in five soil samples at concentrations ranging from 78 ug/kg to 510 ug/kg. Isophrone was detected in both samples of unsaturated soils retained from Boring CSB-10 at concentrations of 3,100 ug/kg in the shallow soil (0.5 to 2 feet) and 1,600 ug/kg in the deeper soil (2 to 4 feet).

Semivolatile organic TICs were detected in every boring. In general, unknowns were the most prevalent class of TICs detected, as each sample contained unknowns. In addition, unknown ketones were detected in 11 of 16 samples.

The lowest total concentrations of TICs were in the two borings (CSB-6 and CSB-7) located south of the former concrete drum storage pad near the property line (see Figure 4-1). The highest total TIC concentrations were detected in Borings CSB-10 through CSB-12. Borings CSB-11 and CSB-12 were located north and east of the former distillation building. Boring CSB-10 was located adjacent to the largest remaining concrete pad. Although the CSB-11 (0.5-2) sample had the highest levels of total TICs (33,900 ug/kg), a duplicate of this sample contained almost 10 times fewer total TICs (3,800 ug/kg). Also, concentrations reported for TICs are estimates only, since the concentrations are calculated using the molecular weight of the compound identified. Especially suspect in this sample is the presence of dioctyl ester hexanedioic acid at 20,000 ug/kg, which was also detected in the laboratory blank but not detected in the duplicate sample.

No trends regarding total TICs or compound variation with increasing depth were apparent. The boring nearest to the concrete office building (CSB-12) contained the greatest variety of TIC compounds. CSB-11 (0.5-2) also contained several different compounds, but the presence of one of these TICs in CSB-11, as stated above, is suspect. It is apparent, however, that soils adjacent to the former distillation building and to the edges of the concrete pads contain the highest total TICs.

4.2.2.3 Pesticides and PCBs

The pesticide 4,4'-DDT (DDT) and two of its associated breakdown products, 4,4'-DDD (DDD) and 4,4'-DDE (DDE), were detected in the onsite soils. The distribution and concentration of these compounds in the soils are shown on Figure 4-1.

DDT was detected in 10 samples at concentrations ranging from 3.9 ug/kg to 99 ug/kg. DDE was detected in 11 samples at levels from 8.6 ug/kg to 310 ug/kg.

DDD was reported in Sample CSB-11 (0.5-2) and the field duplicate at levels of 20 ug/kg and 23 ug/kg. DDD was not reported for these samples by IEA; however, it was determined during the BCM data validation that these results should have been reported (see Appendix H).

No background soil samples were collected; however, from the distribution pattern of these compounds in the soil and the proximity of the site to former agricultural fields, DDT and the related compounds are not site-related. With the exceptions of Borings CSB-6 and CSB-7, DDT and its breakdown products were detected at similar levels throughout the samples. In all samples, DDT was found at lower concentrations than DDE, indicating a long residence time in the soils. In addition, DDT has been banned since 1974, and Chem-Solv, Inc. operated at the site from 1982 through 1984. Thus, DDT is not site-related.

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4.2.2.4 Inorganic Compounds

Nineteen metals were detected in onsite soils. Of these metals, the presence of beryllium and sodium cannot be confirmed in any sample because of contamination of the associated blanks for these parameters. In addition, the presence of nickel, potassium, and zinc in some samples was questioned during data validation. A discussion of the reasons leading to these conclusions may be found in the quality assurance review (Appendix H).

Many inorganic compounds occur naturally in soils. Concentrations of those inorganic compounds detected in onsite soils were compared with literature values for soil levels in the State of Delaware, surrounding states, and the eastern coastal region. Table 4-4 provides a summary of the literature values for these soils, which were used to represent background soil concentrations. Based on a comparison of site data with the background data, only two metals, cadmium and lead, are present in onsite soils at levels greater than background.

The maximum onsite lead concentration is 80 mg/kg, compared with the maximum value for the area of 20 mg/kg. The average onsite lead concentration for all samples was 22 mg/kg, which is close to the background level. Cadmium levels were detected at levels slightly above the typical levels for Delaware soils. The maximum cadmium level detected onsite was 1.7 mg/kg (soils from 0.5 to 2 feet and 2 to 4 feet for Boring CSB-8); the average cadmium level was 0.6 mg/kg. Average cadmium levels in Delaware are 0.17 mg/kg. However, the average cadmium level in soils for the eastern U.S. is 1.8 mg/kg. Therefore, the levels of cadmium found in onsite soils were not above typical levels found in regional soils.

4.2.3 Summary

Low concentrations of organic compounds were detected in onsite soils. These compounds include volatile organics (TCE, chloroform, and methylene chloride), semivolatile organics (benzoic acid, bis[2-ethylhexyl] phthalate, and isophorone), and pesticides (DDD, DDE, and DDT). Nineteen inorganic compounds were detected in onsite soils. Seventeen compounds were detected at concentrations below background soil levels. Only lead and cadmium were found at levels slightly above background literature values. BCM submitted a preliminary review of these data to DNREC and EPA Region III in an Interim Document dated June 1, 1990 (Appendix A-R). EPA concurred with the conclusion that there were no chemicals of concern in site soils (Appendix A-9).

4.3 GROUNDWATER CHARACTERIZATION

Groundwater quality information for the site has been collected since October 1984. From 1984 to November 1988 and from June 1989 to May 1990, DNREC conducted a groundwater monitoring program to characterize the volatile organic constituents of the plume and to monitor its evolution. In December 1985, DNREC installed and operated a groundwater recovery system, and monitored groundwater quality of the untreated and treated water. DNREC analytical results are presented in Appendices B, C, and J.

In April 1990, BCM sampled groundwater from 14 monitoring wells and analyzed it for TCL organic compounds and TAL inorganic compounds. In addition, EPA split samples were retained by FPC personnel from three locations. BCM analytical results and the quality assurance review are contained in Appendix K; EPA analytical results and the quality assurance review are presented in Appendix L.

In February 1991, BCM sampled groundwater from 14 monitoring wells and analyzed it for a variety of parameters (Table 2-3). Split samples were retained by FPC from two locations and submitted to the EPA Region III Central Regional Laboratory (CRL) for analyses. BCM analytical results and accompanying documentation are contained in Appendix M; EPA analytical results and accompanying quality assurance review are presented in Appendix N.

A discussion of groundwater quality for the shallow-zone monitoring wells, the intermediate-zone monitoring wells, and for nearby domestic wells is contained in Section 4.3.1; an assessment of groundwater quality in the vicinity of the site is provided in Section 4.3.2.

In March 1991, DNREC collected samples from three domestic wells and one monitoring well for volatile organic analyses. The domestic wells were also analyzed for manganese, mercury, and zinc.

4.3.1 Groundwater Quality

The following section presents information on groundwater quality for the site from October 1984 to the present. DNREC analytical results from 1984 through 1990 are summarized in Table 4-5; BCM analytical results (April 1990) for shallow-zone and intermediate-zone monitoring wells are summarized in Tables 4-6 through 4-9; and a summary of the analytical results for the EPA split samples (April 1990) is provided in Tables 4-10 and 4-11.

To confirm results obtained in the April 1990 sampling round, selected wells were resampled February 19 through 21, 1991, for volatile organics (26A, 33A, and 41A), mercury (9A and 9B), manganese (26A, 33A, and 39A), and zinc (33A). In addition, 13 of the 14 wells were analyzed for additional water quality parameters. These results are presented in

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Tables 4-12 and 4-13. EPA split-sample results are summarized in Table 4-14. In addition, DNREC sampled three domestic walls (American Roofing, Gearhart/Shane, and Simon) and one monitoring well (39A) on March 4, 1991. DNREC analytical results for March 1991 are presented in Appendix O and summarized in Table 4-15.

4.3.1.1 Shallow-Zone Monitoring Wells

DNREC Investigation Results

Analytical data collected by DNREC for the shallow aquifer have been evaluated over three time periods: (1) the period from October 1984, when the first monitoring wells were sampled, through November 1985, when the groundwater recovery system became operational, (2) the period from December 1985 through November 1988, when the recovery system was in operation, and (3) the period from December 1988 to the present, after groundwater treatment activities ceased. Summaries of groundwater analytical data from 1984 to 1985, from 1986 through 1988, and from 1988 through May 1990 are presented in Table 4-5.

As illustrated in Table 4-5, VOCs were found in the shallow aquifer before the initiation of the groundwater treatment system. Of these VOCs, TCE was identified as the main groundwater contaminant, along with other associated chlorinated hydrocarbons. Maximum detected concentrations of the VOCs ranged from 2.8 micrograms per liter (ug/l) of chlorobenzene to 130,000 ug/l of TCE. The other 12 VOCs and their maximum detected concentrations are: benzene (360 ug/l), chloroform (669 ug/l), 1,1-dichloroethane (414 ug/l), 1,1-dichloroethylene (3,200 ug/l), 1,2-dichloroethane (30 ug/l), trans-1,2-dichloroethylene (1,000 ug/l), ethylbenzene (1,100 ug/l), toluene (2,300 ug/l), 1,1,1-trichloroethane (1,800 ug/l), m-xylene (250 ug/l), o-xylene (106 ug/l), and p-xylene (111 ug/l). These data provided information on the suite of contaminants associated with the Chem-Solv site and with the evolution of the plume before the initiation of the groundwater recovery and treatment system.

Initial sampling of monitoring wells 1A, 2A, 3A, 4A, and 5A in October 1984 showed total VOC concentrations for eight compounds ranging from not detected (Well 3A) to 1,742.1 ug/l in Well 1A (located immediately downgradient from the distillation building). Ethylbenzene (150 ug/l), n-xylene (250 ug/l), o-xylene (27 ug/l), toluene (660 ug/l), 1,1,1-TCA (5.1 ug/l), and TCE (650 ug/l) were detected in Well 1A. By December 1984, total VOCs in Well 1A had increased to 112,730 ug/l, with a TCE level of 110,000 ug/l. The highest level of TCE detected in any of the wells was 130,000 ug/l at Well 1A in January 1985. Since Well 1A was destroyed during soil excavation activities in March 1985, maximum TCE levels in the shallow aquifer may have been higher. Continued monitoring of groundwater quality indicated that by October 1985 the plume had migrated past the northeastern property boundary out to the eastern side of Route 132; total VOC levels in Wells 24A and 25A, located in the median, were 223.8 ug/l and 418 ug/l, respectively; TCE was detected in Wells 27A and 28A at levels of 197 ug/l and 207 ug/l, respectively.

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In December 1985, the groundwater recovery system became operational; analytical results were obtained for both the untreated and treated groundwater. In January 1986, total VOC levels were 37,946 ug/l in the untreated groundwater and 3.5 ug/l in the treated water. Total VOC concentrations in the untreated groundwater gradually decreased to a low of 1.7 ug/l in April 1988 and then increased to levels ranging from 49.4 ug/l in May 1988 to 173.2 ug/l in July 1988. Total VOC levels in the treated water ranged from not detected to 10.5 ug/l. Total VOC isoconcentration maps for November 1986 and June 1987 are shown on Figures 4-2 and 4-3.

After the collapse of the air stripper tower, the groundwater recovery system was shut off in November 1988 and the DNREC groundwater monitoring program was suspended. DNREC resumed the program in June 1988; however, much of this sampling program focused on monitoring local downgradient domestic wells. Since the recovery system was shut off, sampling of monitoring wells has been limited to an individual well in the area of the recovery system. No volatiles were detected in Well 5A in February 1990.

Remedial Investigation Results

A summary of EPA split-sample results is presented in Tables 4-10 and 4-11. Groundwater analytical results for samples obtained in April 1990 and analyzed for TCL organic compounds and TAL inorganic compounds are presented in Tables 4-6 through 4-9. Isoconcentration maps for total VOCs, total volatile tentatively identified compounds (TICs), and total semivolatile TICs are shown on Figures 4-4 through 4-6. Additional groundwater samples were obtained in February 1991 from selected wells to confirm results obtained in April 1990. Summaries of these results are provided in Tables 4-12 and 4-13. A summary of EPA split-sample results is presented in Table 4-14.

Nine volatile organic compounds -- acetone, benzene, 1,2-dichloroethane (1,2-DCA), methylene chloride, tetrachloroethene (PCE), toluene, 1,1,1-trichloroethane (1,1,1-TCA), trichloroethene, and total xylenes -- were found during the April 1990 sampling round in five of the nine shallow wells (Table 4-6). Total VOC concentrations ranged from 5 ug/l in Well MHS-5-18 to 563 ug/l in Well 33A to 921 ug/l in Well MHS-7-25. Twelve volatile TICs were found in two of the wells at total concentrations of 6,800 ug/l and 2,660 ug/l for Well 26A and 2,640 ug/l for MHS-7-25. The presence of 1,2-DCA in Well MHS-7-25 was questioned after a review of the supporting documentation (Appendix K).

In February 1991, three wells (26A, 33A, and 41A) were resampled and analyzed for volatile organics. Generally, the levels of volatile organics detected in the groundwater were lower in February 1991 than in April 1990. No volatiles were detected in Well 41A. Benzene was detected in Well 26A at 29 ug/l; substituted benzenes were also

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tentatively identified in this well. TCE, PCE, and 1,1,1-TCA were detected in the onsite well, 33A, at 115 ug/l (average value of the sample and its duplicate), 4 ug/l, and 10 ug/l, respectively. PCE had not been detected in Well 33A in April 1990; however, both TCE and 1,1,1-TCA levels were much lower than the 1990 levels (115 ug/l versus 540 ug/l for TCE and 10 ug/l versus 127 ug/l for 1,1,1-TCA).

Phenol was found in only one well (MWS-7-25), at an estimated concentration of 9 ug/l. Eleven semivolatile TICs were detected in three of the offsite shallow zone monitoring wells (26A, 41A, and MWS-7-25). No pesticides were found in any groundwater sample.

Both filtered and unfiltered groundwater samples were obtained from all wells and analyzed for TAL inorganic compounds. Twenty inorganics were detected in these samples (Table 4-7). These data were evaluated by comparing detected concentrations in the filtered versus the unfiltered samples for each well and by comparing detected concentrations versus the background levels found in Well 22A. Aluminum, barium, calcium, chromium, cobalt, iron, magnesium, manganese, potassium, selenium, sodium, and zinc were all found at higher levels in the filtered than in the unfiltered sample for at least one sample. EPA Region III QA guidance for groundwater filtration procedures and data evaluation (EPA, April 23, 1990) indicates that there may be several causes for this, specifically errors in sample labeling (when nearly all filtered concentrations are higher for a particular sample) and contamination from improperly cleaned filters (when iron, zinc, aluminum, and copper are higher in the filtered samples). Since the majority of the metals results for all samples show higher levels in the unfiltered samples, there do not appear to be labeling errors. To evaluate the possibility of contamination from improperly cleaned sampling equipment, results for the duplicate samples (Well 26A) and the field blanks were reviewed. With the exception of cobalt, all of the instances where a high concentration was found in the filtered sample were not repeated in a duplicate sample.

In addition, arsenic, barium, calcium, cobalt, iron, magnesium, potassium, sodium, and zinc were found at higher levels in the filtered than in unfiltered samples for at least one field blank. The instances of higher concentrations of metals in the filtered samples do not seem to represent sample labeling or equipment decontamination problems, but appear to be a function of analytical method precision and accuracy. The results (Table 4-7) show two major trends, which support the method variability assumption. When filtered samples had higher concentrations than unfiltered samples, they generally contained the following metals: sodium, calcium, magnesium, manganese, and potassium were found. These metals are matrix defining (as in salts) and are present at higher concentrations. The analytical system precision decreases as concentrations increase. The other trend was noted at the lowest concentration metals reported, where the analyte may or may not be

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detected at or near the required detection limit. The differences of concentration between the reported filtered and unfiltered aliquots do not appear to show analytical disparity.

Inorganic results were also compared with background groundwater quality, represented by Well 22A. Aluminum, barium, calcium, chromium, iron, manganese, mercury, potassium, sodium, vanadium, and zinc were found in at least one shallow well at levels greater than five times the background levels. Manganese and sodium were found in most or all of the downgradient wells at levels greater than background.

To confirm elevated levels of manganese, mercury, and zinc detected in several downgradient wells, several wells were resampled in February 1991. Levels of manganese in Wells 26A, 33A, and 39A and levels of zinc in Well 33A, which had been detected in April 1990, were confirmed by results of the February 1991 resampling. Additional groundwater quality parameters (biochemical oxygen demand, dissolved oxygen, and so on) were measured in 14 of these wells to evaluate whether anaerobic groundwater conditions exist. Many inorganic compounds, including manganese, become more soluble in water under anaerobic conditions. The highest manganese concentration (25,400 ug/l) was found in Well 26A. Low pH and dissolved oxygen (DO) concentrations for this well indicate anaerobic conditions. Groundwater from several other locations (33A and 39A) also has low pH and DO concentrations. However, the patterns of manganese and zinc concentrations were dissimilar; zinc levels were elevated in 33A but not 39A, and manganese levels were elevated in 39A but not 33A.

In April 1990, mercury had been detected in Well 9B at levels up to 2.8 ug/l. In February 1991, both 9A and 9B were sampled and analyzed for mercury. Well 9A had not been sampled in April 1990; however, it was included in the sampling event to define mercury concentrations in the shallow zone. In addition, since the maximum contaminant level (MCL) for mercury in water (2 ug/l) is based on toxicity information for inorganic mercury, these wells were also analyzed for inorganic mercury in accordance with the method presented in the Sampling Plan. Although the levels of mercury detected in Well 9B were similar to those recorded in April 1990, no mercury was detected in the shallow aquifer at that location (Well 9A). Thus, Chem-Solv is not the source of the mercury levels in Well 9B.

EPA Split-Sample Results

In April 1990, split groundwater samples from Wells 41A and MWS-5-18 were provided to personnel from FPC for analyses. Summaries of these analytical results are contained in Tables 4-10 and 4-11. The EPA data validation reports containing the analytical results sheets and documentation are contained in Appendix L. In February 1991, split groundwater samples were provided to FPC personnel for analyses. A summary of these results is presented in Table 4-14.

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BCM

EPA split-sample results for organic compounds generally agreed with the BCM data. In April 1990, EPA detected chloroform at an estimated concentration of 2 ug/l in Well MWS-5-18. Chloroform was undetected in the BCM data for this well; however, this does not represent a serious discrepancy, because of the low level detected by EPA. Total semivolatile TICs found in the EPA and BCM data for Well 41A were at 48 ug/l and 86.1 ug/l, respectively. No pesticides were detected for any sample.

In April 1990, detected concentrations of inorganic compounds for both the EPA and BCM data sets generally were within 10 percent of each other. Except for antimony, which was not detected in any BCM result, the detected compounds for the split samples were the same. In addition, barium was detected in the filtered samples above the levels in the unfiltered samples for both wells. This pattern agrees with the pattern seen in the BCM data set and is probably a function of analytical precision and accuracy.

4.3.1.2 Intermediate-Zone Monitoring Wells

DNREC Investigation Results

From October 1984 through November 1985, six volatile organic compounds were found in intermediate-zone monitoring wells (Table 4-4). These compounds -- chloroform, 1,1-dichloroethane (1,1-DCA), 1,2-dichloropropane, toluene, 1,1,1-TCA, and TCE -- were detected infrequently in onsite Wells 5B and 9B. No organic compounds were ever detected in the upgradient well (6B) or in the offsite side gradient and downgradient wells (7B and 8B). The maximum detected VOC levels detected were 1.3 ug/l (chloroform), 1.2 ug/l (1,1-DCA), 38 ug/l (1,2-dichloropropane), 2.3 ug/l (toluene), 2.1 ug/l (1,1,1-TCA), and 3.4 ug/l (TCE). No semivolatile organic compounds were found in any well during the December 1984 sampling.

During groundwater remediation activities, the total VOC concentrations for the onsite intermediate zone wells ranged from not detected to 44.5 ug/l (Well 9B).

Remedial Investigation Results

In April 1990, low concentrations of volatile and semivolatile compounds were found in the two onsite wells and the upgradient well (Table 4-8). TCE was detected in Well 5B at an estimated concentration of 5 ug/l and was undetected in Well 9B at the quantitation limit. Total semivolatile TICs were 10 ug/l in the upgradient well (MWI-1-43), 103 ug/l in Well 5B, and 60 ug/l in Well 9B. No volatile TICs, semivolatile organic compounds, or pesticides were detected in any groundwater sample.

BCM

In April 1990, mercury was detected in Well 9B at levels of 2.85 ug/l (average of samples and its duplicate) in the unfiltered samples and 2.7 ug/l (average of duplicate samples) in the filtered sample. In February 1991, Well 9B was resampled for mercury; Well 9A was also sampled to determine whether mercury was present in the shallow aquifer zone. In addition, these samples were analyzed for inorganic mercury since the maximum contaminant level (MCL) for mercury (2 ug/l) is based on toxicity information for inorganic mercury. Both total and inorganic mercury were undetected in the samples from Well 9A.

The concentrations of total mercury detected in Well 9B in April 1990 were similar to the results of the February 1991 samples. Inorganic mercury concentrations in Well 9B were higher in the unfiltered sample (2.6 ug/l) than in the filtered sample (0.3 ug/l), indicating that much of the inorganic mercury is not dissolved in groundwater. However, the total mercury concentrations for both filtered and unfiltered samples (2.2 ug/l and 2.1 ug/l, respectively) were less than the inorganic mercury concentration. The high inorganic mercury concentrations reported may be due to matrix interferences as a result of the modifications made to the standard mercury method for these analytes.

EPA Results

Field duplicate samples were analyzed in April 1990 from Well 9B (Tables 4-10 and 4-11). No organic compounds were detected in either sample. Twelve inorganic compounds (aluminum, antimony, barium, calcium, iron, lead, magnesium, manganese, mercury, potassium, sodium, and zinc) were detected. Field duplicate results were generally within 20 percent of each other and with the BCM split samples. However, the aluminum concentration in Sample 9BD (227 mg/l) was twice the level in the duplicate sample (114 mg/l); aluminum concentrations for the BCM split samples were 428 mg/l and 398 mg/l.

4.3.1.3 Domestic Wells

Up to 14 domestic wells located down or side gradient from the site have been monitored since October 1984. The majority of these wells collect water from deeper zones in the aquifer (greater than 100 feet below ground surface); the total depth of some of these wells is less than 50 feet or is unknown (CABE, 1987). DNREC analytical data indicated that low concentrations of VOCs had been detected in some of the residential wells. A replacement well was installed on the Gearhart property because of the presence of VOCs; however, this well was apparently improperly installed and became contaminated with groundwater from the shallow aquifer. A new well was installed to a deeper depth.

No volatile organic compounds were detected in the Simon domestic well, which DNREC sampled in March 1991. One volatile compound, 1,2-DCA, was detected in the American Roofing well at 5 ug/l.

AR307554

4.3.2 Assessment of Groundwater Quality

Data from the historic data base were used to evaluate the horizontal and vertical migration of the site-related plume from a period shortly after the explosion and fire in October 1984 to November 1988, when the groundwater recovery system was shut down. Data collected during RI field activities were used to confirm the information collected by DNREC and to monitor any further plume migration since the cessation of groundwater remediation activities. In addition, these data were used to provide additional data necessary to characterize semivolatile compounds, pesticides, and inorganic compounds in both the shallow- and intermediate-aquifer zones.

Groundwater quality information obtained during this and previous investigations indicates that groundwater from the shallow aquifer beneath and downgradient of the site has been affected by site activities that produced organic compounds, primarily TCE and related compounds. In addition, manganese and zinc have been detected in wells located onsite and downgradient from the site. TCE and other organic compounds were present in the shallow groundwater from the area beneath the former distillation building to the eastern edge of Route 13. Impact to the deeper zones of the aquifer has been limited by the presence of a silt layer approximately 20 feet below the ground surface in the vicinity of the site. However, some VOC contamination of the intermediate zone has occurred, as indicated by low levels of VOCs in the intermediate-zone monitoring wells and nearby domestic wells.

Historical analytical data show that TCE in the shallow groundwater reached levels up to 130,000 ug/l in Well 1A. The operation of a groundwater recovery system prevented much of the TCE from migrating offsite. The maximum TCE level detected in the wells located in the Route 13 median (24A, 24B, and 39A) before the initiation of the groundwater recovery system was 389 ug/l in October 1985; after the initiation of groundwater treatment in December 1985, TCE concentrations in these wells reached a maximum of 460 ug/l in July 1986 at Well 39A but dropped to 233 ug/l by November 1986. In April 1990, TCE concentrations had decreased to 6 ug/l offsite (Well 39A) and 540 ug/l. By February 1991, onsite TCE levels had dropped to 115 ug/l, while offsite concentrations decreased (Well 26A).

In addition, a second distinct plume has been identified just north of the intersection of Routes 13 and 42. Groundwater quality for Well MMS-7-25 differs from groundwater quality associated with the site; the types and concentrations of the compounds detected in this well are dissimilar to the pattern associated with site groundwater contamination. Groundwater containing acetone, benzene, 1,2-DCA, and xylenes, as well as benzene-, pentane-, and hexane-related TICs, was found in Well MMS-7-25. Benzene and xylenes are hydrocarbons generally associated with a fuel source, such as an underground storage tank, and not with the solvent source identified for the Chem-Solv site. Benzene was found in Well MMS-7-25 at a concentration of 830 ug/l; the maximum

BCM

benzene concentration found in groundwater onsite or near the site was 200 ug/l (Well 26A). The presence of benzene in MMS-7-25 at concentrations much greater than levels found near the site and the fact that the maximum benzene concentration detected during the DNREC monitoring program was 360 ug/l, indicates that groundwater quality for this well has been influenced by a source or sources other than the Chem-Solv site.

Information obtained from the DNREC Underground Storage Tank Branch indicated that there are several potential offsite sources for the organic compounds in groundwater at Well MMS-7-25 (Appendix A). Soil samples were obtained during the removal of underground storage tanks at a gas station northwest of the intersection of Route 13 and Route 42. Benzene, ethylbenzene, toluene, xylene, and total petroleum hydrocarbons were found at levels of 2.1 mg/kg, 10 mg/kg, 16 mg/kg, >300 mg/kg, and 410 mg/kg, respectively. The levels of these compounds present in the soil at a location directly upgradient to Well MMS-7-25 indicate that leaking underground storage tanks at this location are the probable source of the benzene, toluene, xylene, and related compounds found in groundwater at Well MMS-7-25.

The benzene, xylene, toluene, and other TICs identified in Well MMS-7-25 have been interpreted to be representative of compounds found in the subsurface after gasoline or other petroleum hydrocarbons (No. 2 fuel oil or jet oil) are spilled (Appendix A-11). No compounds found in this well are associated with Chem-Solv. The benzene was detected at a concentration four times as great as the maximum levels detected in the historical data; 1,2-DCA, which was detected in this well at an estimated concentration of 16 ug/l, is not a degradation product of TCE (Appendix A-11). Therefore, groundwater quality at this location has been affected by a source or sources other than the Chem-Solv site.

Manganese, mercury, and zinc were detected in April 1990 at levels above background in several wells. However, according to analytical data obtained in February 1991, the mercury present in Well 9B is not site-related, because mercury was undetected in the shallow well at the same location (9A). Zinc was elevated in one well, the onsite shallow well, but was not elevated above background in any of the downgradient wells.

The highest manganese concentrations were found in Well 26A, located downgradient of the site. Manganese levels onsite at Well 33A did not exceed background. However, elevated manganese levels were found in the wells downgradient of Well 26A. The high manganese concentrations in Well 26A may have resulted from increased manganese solubility due to anaerobic conditions. However, the cause of the low DO and pH at this location is unknown. Other wells with low DO and pH have manganese levels that are lower by an order of magnitude. Therefore, the source of the elevated manganese in the groundwater is unknown. However, the highest manganese levels were found in Well 26A, which has been affected by an offsite source or sources.

AR307556

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SECTION 4.0

FIGURES

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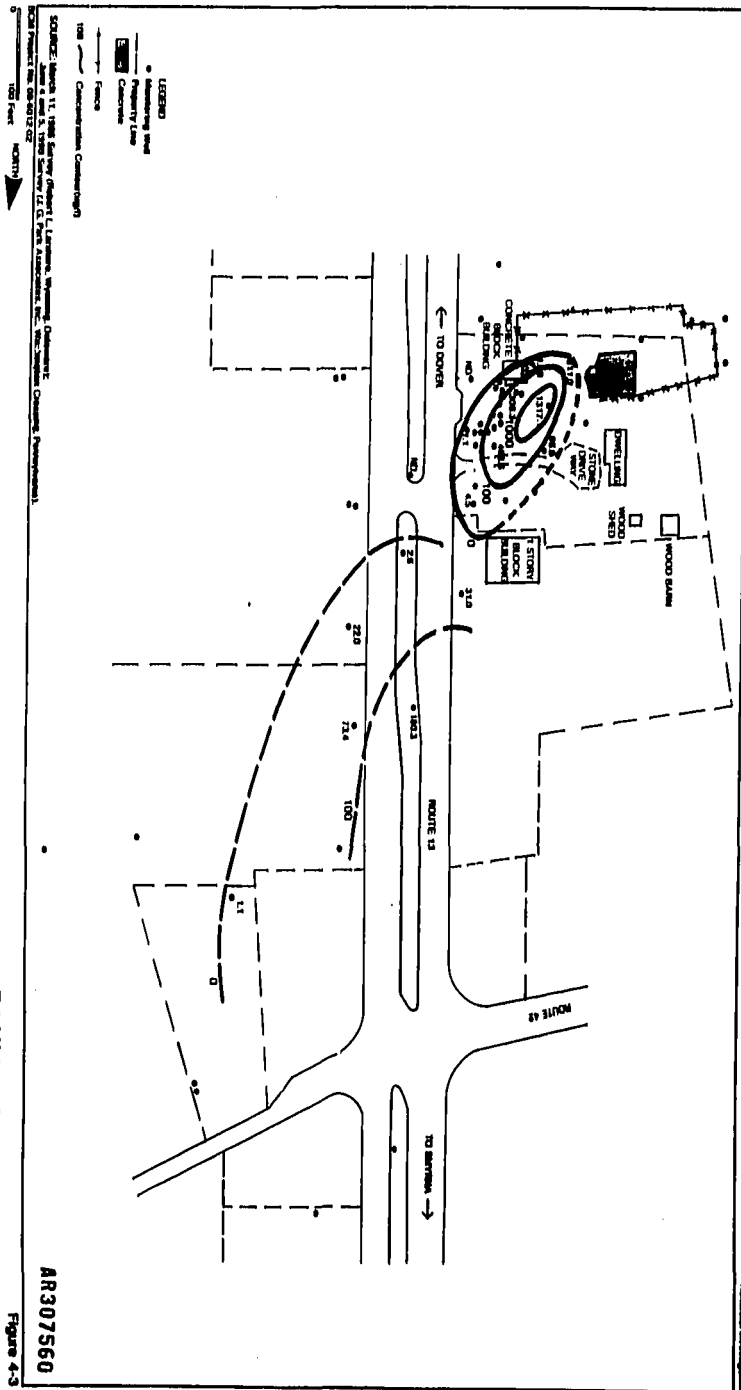
**CHEM-DRY, INC. 3175
Riverside Drive**



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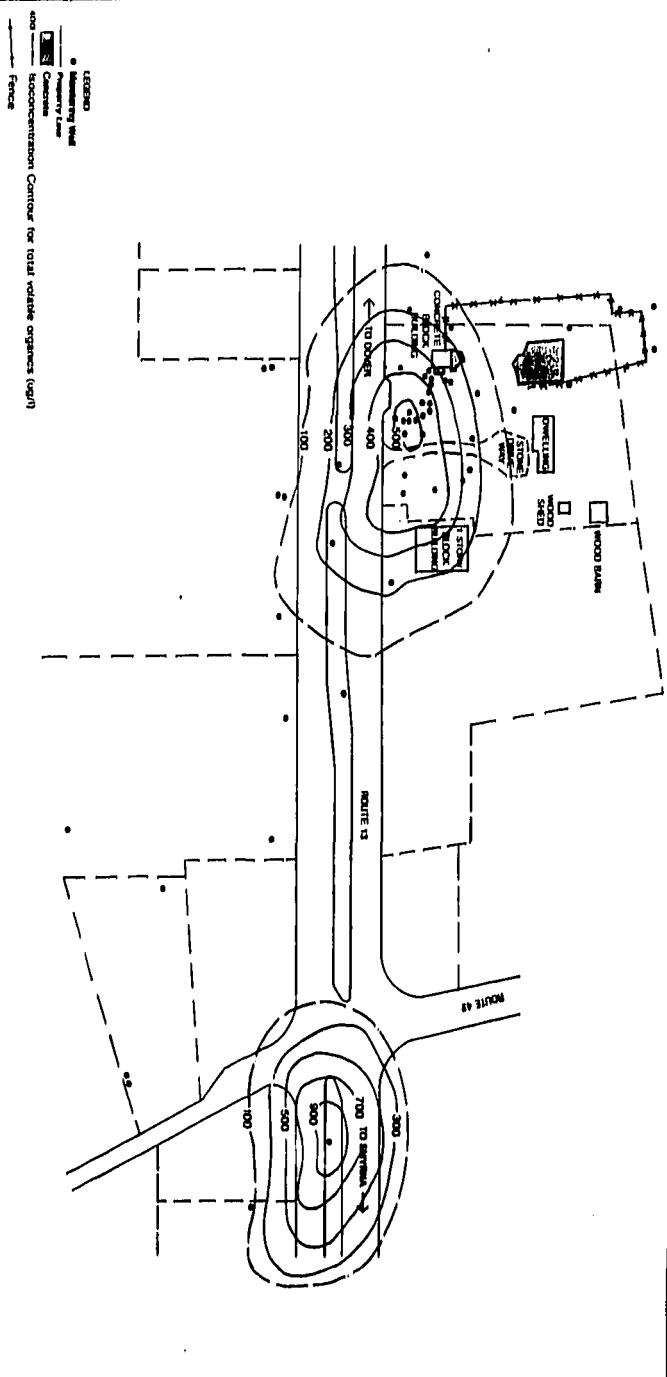
CHASCOY, NE, NE



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ECM

CHS-ACLY, INC. SITE
Remedial Investigation



AR307561

Figure 4-4
Total Volatile Organics in Shadow Greenwater
April 1990

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BCM

SECTION 4.0

TABLES

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TABLE 4-1

AIR INVESTIGATION RESULTS

CHEM-SOLV, INC. SITE REMEDIAL INVESTIGATION
CHESWOLD, DELAWARE

LOCATION	TIME	ORGANIC VAPOR READINGS	
		OVA	HNu
1	1145	0.4	NIR
2	1147	0.4	NIR
3	1148	0.8	NIR
4	1148	0.8	NIR
5	1149	0.8	NIR
6	1149	1.0	NIR
7	1150	1.0	NIR
8	1151	1.2	NIR
9	1152	1.5	NIR
10	1153	1.6	NIR
11	1154	1.7	NIR
12	1155	1.9	NIR

NIR No instrument response

Air monitoring survey performed October 18, 1989; winds from the
west-southwest

All organic vapor readings recorded above background levels

Source: BCM Engineers Inc. (BCM Project No. 00-6012-02)

AR307563



TABLE 4-2

SUMMARY OF SOIL ANALYTICAL RESULTS
CHEM-SOLV, INC. SITE REMEDIAL INVESTIGATION
CHESWOLD, DELAWARE

IEA Organic Sample No.:	BCM07	BCM08	BCM11	BCM05	BCM06	BCM12	BCM28
IEA Inorganic Sample No.:	BCM07	BCM08	..	BCM05	BCM06	..	BCM28
BCM Sample No.:	000844	000845	000846	000848	000849	000848	004998
Sample Date:	12/14/89	12/14/89	12/15/89	12/13/89	12/13/89	12/14/89	02/22/90
Sample Name:	C5B-6	C5B-6	C5B-6	C5B-7	C5B-7	C5B-7	C5B-6
	(D-5-2)	(E-7-3)	(F-8-18-9)	(A-6)	(B-10)	(D-5-20-8) *	(D-5-2) **
Parameter (Units)							
<u>Volatiles Organics (ug/g)</u>							
Acetone	12.0 BQ	73.0 BQ	13.0 BQ	400.0 BQ	69.0 BQ	56.0 BQ	10.0 BQ
Chloroform	6.0 U	5.0 J	4.0 J	15.0	8.0	4.0 J	6.0 U
Methylene Chloride	12.0 BQ	8.0 BQ	3.0 BQ	11.0 U	7.0 BQ	3.0 BQ	9.0 BQ
Trichloroethene	6.0 U	6.0 U	5.0 U	11.0 U	6.0 U	5.0 U	6.0 J
Total Volatiles	ND	5.0	4.0	15.0	8.0	4.0	5.0
<u>Volatiles Organics (Temporary Identifying Compounds) (ug/g)</u>							
Hexane	ND	ND	ND	ND	ND	ND	ND
Pentane, 2-methyl-	ND	ND	ND	ND	ND	ND	ND
Pentane, 3-methyl-	ND	ND	ND	ND	ND	ND	ND
Sisane, trimethyl-	ND	ND	ND	ND	ND	ND	ND
Unknown (Total)	ND	ND	ND	ND	ND	ND	ND
Unknown Hydrocarbon	ND	ND	ND	ND	ND	ND	ND
Total Volatile TICs	ND	ND	ND	ND	ND	ND	ND
<u>Semi-volatile Organics (ug/g)</u>							
Benzoic Acid	1,900.0 U	1,900.0 U	NT	1,800.0 U	2,000.0 U	NT	1,900.0 U
bis(2-Ethylhexyl) phthalate	370.0 U	380.0 U	NT	370.0 U	380.0 U	NT	370.0 U
Isophenone	370.0 U	380.0 U	NT	370.0 U	380.0 U	NT	370.0 U
Total Semi-volatiles	ND	ND	NT	ND	ND	NT	ND
<u>Semi-volatile Organics (Temporary Identifying Compounds) (ug/g)</u>							
1-Hexanol, 2-ethyl-	ND	ND	NT	ND	ND	NT	ND
ODE Isomer (27.86)	ND	ND	NT	ND	ND	NT	ND
Hexanediol and, diethyl ox (28.27)	ND	ND	NT	ND	ND	NT	ND
Methanone (18.86)	ND	ND	NT	ND	ND	NT	ND
Substituted Phenol (Total)	ND	ND	NT	ND	ND	NT	ND
Trichloropropene Isomer (10.42)	ND	ND	NT	ND	ND	NT	ND
Unknown (Total)	1,100.0	400.0	NT	500.0 A	200.0	NT	600.0
Unknown Aromatics (28.27)	ND	ND	NT	ND	ND	NT	ND
Unknown Chloroalkanes (13.38)	ND	ND	NT	ND	ND	NT	ND
Unknown Acid	ND	ND	NT	ND	ND	NT	ND
Unknown Hydrocarbon (6.48)	ND	ND	NT	ND	ND	NT	ND
Unknown Ketone (Total)	300.0	ND	NT	ND	ND	NT	1,900.0
Total Semi-volatile TICs	1,400.0	400.0	NT	500.0	200.0	NT	2,900.0
<u>Pesticides (ug/g)</u>							
4,4-DDD	18.0 U	18.0 U	NT	18.0 U	18.0 U	NT	44.0
4,4-DDD	18.0 U	18.0 U	NT	18.0 U	18.0 U	NT	9.3 U
4,4-DDT	18.0 U	18.0 U	NT	18.0 U	18.0 U	NT	25.0
<u>Inorganic Compounds (mg/g)</u>							
Aluminum	17,800.0	18,100.0	NT	15,700.0	11,300.0	NT	10,700.0
Arsenic	2.0 (I)	0.89 (I)	NT	1.6 (I)	0.97 (I)	NT	3.5
Barium	49.0	34.0 (I)	NT	25.5 (I)	32.6 (I)	NT	42.0
Beryllium	0.14 U	0.14 U	NT	0.18 U	0.18 U	NT	0.13 U
Cadmium	0.82 U	0.86 U	NT	0.7 U	0.71 U	NT	0.81 U
Calcium	978.0 (J)	236.0 (J)	NT	272.0 (J)	245.0 (J)	NT	308.0 (I)
Chromium	15.8	7.1	NT	8.8	9.0	NT	8.2
Cobalt	2.3 (I)	2.2 (I)	NT	4.1 (I)	2.4 U	NT	3.7 (I)
Copper	4.6 (I)	1.8 (I)	NT	3.8 (I)	2.5 (I)	NT	5.7
Iron	15,800.0	8,630.0	NT	9,980.0	7,480.0	NT	8,430.0
Lead	7.0	5.3	NT	7.0	5.5	NT	19.8
Magnesium	1,030.0	411.0 (I)	NT	465.0 (I)	940.0 (I)	NT	578.0 (I)
Manganese	75.7	61.8	NT	88.9	88.8	NT	126.0
Nickel	6.8	7.8 (I)	NT	8.3 (JQ)	7.5 (JQ)	NT	4.4 (JQ)
Potassium	631.0 (JQ)	374.0 (JQ)	NT	521.0 (JQ)	788.0 (JQ)	NT	431.0 (JQ)
Selenium	0.38 U	0.38 U	NT	0.38 U	1.4 U	NT	0.38 U
Sodium	19.8 (JQ)	20.0 (JQ)	NT	19.0 (JQ)	28.1 (JQ)	NT	66.1 (JQ)
Vanadium	25.1	16.3	NT	17.2	12.3	NT	14.7
Zinc	20.8	13.6 Q	NT	14.7	14.5	NT	24.0 J

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IEA Organic Sample No.:	BCM29	BCM30	BCM33	BCM36	BCM37	BCM43	BCM39
IEA Inorganic Sample No.:	BCM29	BCM30	..	BCM36	BCM37	..	BCM39
BCM Sample No.:	004997	004998	005268	008791	008792	008793	008794
Sample Date:	02/22/90	02/22/90	02/26/90	02/27/90	02/27/90	02/27/90	02/27/90
Sample Name:	CSB-8D	CSB-8	CSB-8A	CSB-9	CSB-9	CSB-9	CSB-10
	(0.5-2) **	(2-4)	(16-20)	(2-4)	(4-5.5)	(19.5-20)	(0.5-2)
Parameter (Units)							
Volatile Organics (ug/lb)							
Acetone	12.0 BQ	12.0 BQ	12.0 BQ	16.0 BQ	16.0 BQ	15.0 BQ	11.0 BQ
Chloroform	6.0 U	6.0 U	6.0 U	6.0 U	6.0 U	6.0 U	6.0 U
Methylene Chloride	9.0 BQ	8.0 BQ	10.0 BQ	4.0 J	6.0 U	6.0 BQ	6.0 U
Trichloroethene	6.0 U	6.0 U	6.0 U	6.0 U	6.0 U	6.0 U	6.0 U
Total Volatiles	ND	ND	ND	4.0	ND	ND	ND
Volatile Organics Tentatively Identified							
Compounds (ug/lb)							
Hexane	ND	ND	ND	ND	ND	ND	ND
Pentane, 2-methyl-	ND	ND	ND	ND	ND	ND	ND
Pentane, 3-methyl-	ND	ND	ND	ND	ND	ND	ND
Silanol, trimethyl-	ND	ND	ND	ND	ND	ND	ND
Unknown (Total)	ND	ND	ND	ND	ND	ND	ND
Unknown Hydrocarbon	ND	ND	ND	ND	ND	ND	ND
Total Volatile TICs	ND	ND	ND	ND	ND	ND	ND
Semivolatile Organics (ug/lb)							
Boric Acid	1,900.0 U	1,900.0 U	NT	1,900.0 U	1,900.0 U	NT	2,000.0 U
bis(2-Ethylhexyl) phthalate	380.0 U	75.0 J	NT	110.0 J	510.0	NT	380.0 U
Isophthalene	380.0 U	370.0 U	NT	380.0 U	370.0 U	NT	3,100.0
Total Semivolatiles	ND	75.0	NT	110.0	510.0	NT	3,100.0
Semivolatile Organics Tentatively Identified							
Identified Compounds (ug/lb)							
1-Hexanol, 2-ethyl-	ND	ND	NT	ND	ND	NT	ND
DOE Isomer (27.86)	ND	ND	NT	ND	ND	NT	ND
Hexadecanoic acid, dodecyl est (29.27)	ND	ND	NT	ND	ND	NT	ND
Methanamine (18.86)	ND	ND	NT	ND	ND	NT	ND
Substituted Phenol (Total)	ND	ND	NT	ND	ND	NT	ND
Trichloropropene Isomer (10.42)	ND	ND	NT	ND	ND	NT	ND
Unknown (Total)	1,000.0	2,000.0	NT	1,200.0	1,800.0	NT	1,000.0
Unknown Aromatic (36.27)	ND	ND	NT	ND	ND	NT	ND
Unknown Chlorocarbon (13.38)	ND	ND	NT	ND	ND	NT	ND
Unknown Acid	ND	ND	NT	200.0 J	ND	NT	ND
Unknown Hydrocarbon (8.45)	ND	ND	NT	ND	ND	NT	ND
Unknown Ketone (Total)	3,700.0	900.0	NT	5,000.0	4,800.0	NT	5,000.0
Total Semivolatile TICs	4,700.0	2,800.0	NT	6,200.0	6,400.0	NT	6,000.0
Phthalates (ug/lb)							
4,4'-DDE	56.0	37.0	NT	110.0	6.6 J	NT	100.0
4,4'-DDD	9.1 U	9.1 U	NT	10.0 U	10.0 U	NT	10.0 U
4,4'-DDT	31.0	17.0	NT	61.0	3.9 J	NT	31.0
Inorganic Compounds (mg/lb)							
Aluminum	14,900.0	13,000.0	NT	10,800.0	15,400.0	NT	8,580.0
Arsenic	2.7	4.0	NT	10.7	2.1	NT	5.3
Barium	50.8	59.8	NT	100.0	44.8 J	NT	72.9
Beryllium	0.87 JQ	0.63 JQ	NT	0.89 JQ	0.89 JQ	NT	0.89 JQ
Calcium	1.7	1.7	NT	1.5	1.2	NT	0.81 U
Calcium	586.0 J	583.0 J	NT	1,860.0	481.0 J	NT	886.0 J
Chromium	12.6	12.1	NT	11.2	8.0	NT	10.8
Cobalt	5.4 J	5.8 J	NT	6.1 J	6.0 J	NT	4.4 J
Copper	9.5	5.2	NT	14.0	3.9 J	NT	11.2
Iron	11,800.0	12,700.0	NT	11,600.0	10,000.0	NT	8,360.0
Lead	24.2	23.0	NT	34.1	6.9	NT	36.1
Magnesium	662.0 J	603.0 J	NT	707.0 J	402.0 J	NT	623.0 J
Manganese	138.0	136.0	NT	258.0	101.0	NT	131.0
Nickel	4.8 JQ	4.5 JQ	NT	5.8 J	4.8 J	NT	4.8 J
Potassium	488.0 JQ	507.0 JQ	NT	488.0 JQ	570.0 JQ	NT	488.0 JQ
Selenium	0.26 U	0.27 J	NT	0.21 U	0.18 U	NT	0.26 U
Sodium	62.2 JQ	102.0 JQ	NT	127.0 JQ	107.0 JQ	NT	141.0 JQ
Vanadium	16.8	19.7	NT	13.5	16.2	NT	13.5
Zinc	32.1 J	23.5 J	NT	73.9 J	16.0 J	NT	91.0 J

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BCM

IEA Organic Sample No	BCM38	BCM42	BCM20	BCM21	BCM22	BCM25	BCM16
IEA Inorganic Sample No	BCM38	..	BCM14	BCM15	BCM16	..	BCM10
BCM Sample No.	008795	008796	000856	000857	000858	000861	000852
Sample Date:	02/27/90	02/27/90	12/19/89	12/19/89	12/19/89	12/20/89	12/18/89
Sample Name:	C58-10	C58-10	C58-11	C58-110	C58-11	C58-11	C58-12
	(2-4)	(18-18.5)	(0.5-2)	(0.5-2)	(5-8)	(20.4-20.7)	(0.5-2)
Parameter (Units)							
<u>Volatile Organics (ug/kg)</u>							
Aceone	12.0 BJQ	19.0 BO	12.0 U	12.0 U	11.0 U	10.0 U	11.0 U
Chloroform	8.0 U	8.0 U	8.0 U	8.0 U	8.0 U	8.0 U	8.0 U
Methylene Chloride	8.0 U	15.0 BO	8.0 U	8.0 U	8.0 U	8.0 U	8.0 U
Trichloroethene	8.0 U	8.0 U	8.0 U	8.0 J	8.0 U	8.0 U	8.0 U
Total Volatiles	ND	ND	ND	8.0	ND	ND	ND
<u>Volatile Organic Tentatively Identified Compounds (ug/kg)</u>							
Heptane	ND	ND	ND	ND	ND	ND	ND
Perthane, 2-methyl-	ND	ND	ND	ND	ND	ND	ND
Perthane, 3-methyl-	ND	ND	ND	ND	ND	ND	ND
Stanol, trimethyl-	ND	ND	ND	ND	ND	ND	10.0 J
Unknown (Total)	ND	ND	ND	ND	ND	ND	10.0 J
Unknown Hydrocarbon	ND	ND	ND	ND	ND	ND	ND
Total Volatile TICs	ND	ND	ND	ND	ND	ND	30.0
<u>Semivolatile Organics (ug/kg)</u>							
Benzene Acid	1,800.0 U	NT	1,900.0 U	1,900.0 U	1,900.0 U	NT	880.0 J
Is(2-Ethylhexyl) phthalate	180.0 J	NT	380.0 U	380.0 U	370.0 U	NT	440.0 J
Isophthalene	1,800.0	NT	380.0 U	380.0 U	370.0 U	NT	380.0 U
Total Semivolatiles	1,780.0	NT	ND	ND	ND	NT	1,080.0
<u>Semivolatile Organic Tentatively Identified Compounds (ug/kg)</u>							
1-Heptanol, 2-ethyl-	ND	NT	ND	ND	ND	NT	ND
ODE Isomer (27.28)	ND	NT	200.0 J	ND	ND	NT	ND
Hexadecanoic acid, isooctyl est (28.37)	ND	NT	20,000.0 BJ	ND	ND	NT	4,000.0 BJ
Nonadecane (18.88)	ND	NT	ND	ND	ND	NT	ND
Subsaturated Phenol (Total)	ND	NT	800.0	300.0	300.0	NT	ND
Trichloropropene Isomer (10.42)	ND	NT	ND	ND	ND	NT	ND
Unknown (Total)	5,100.0	NT	7,800.0	2,400.0	400.0	NT	2,850.0
Unknown Aromatic (28.37)	ND	NT	ND	ND	ND	NT	300.0 J
Unknown Chlorocarbon (13.38)	ND	NT	ND	ND	ND	NT	ND
Unknown Acid	ND	NT	ND	ND	ND	NT	ND
Unknown Hydrocarbon (8.45)	ND	NT	ND	ND	ND	NT	ND
Unknown Ketone (Total)	6,000.0	NT	6,000.0	1,200.0	ND	NT	1,200.0
Total Semivolatile TICs	11,100.0	NT	33,900.0	3,800.0	800.0	NT	6,300.0
<u>Polycyclic Aromatic Hydrocarbons (ug/kg)</u>							
4,6-DDC	48.0	NT	240.0	310.0	18.0 U	NT	180.0
4,6-DDO	10.0 U	NT	30.0	23.0	18.0 U	NT	18.0 U
4,6-DDT	8.4 J	NT	88.0	98.0	18.0 U	NT	81.0
<u>Inorganic Constituents (ug/kg)</u>							
Aluminum	8,510.0	NT	12,900.0	11,300.0	16,300.0	NT	10,200.0
Antine	8.6	NT	7.9	8.2	0.87 (J)	NT	8.2
Barium	53.9	NT	108.0	97.2	37.8 (J)	NT	88.2
Bismuth	0.7 (JQ)	NT	0.18 U	0.18 U	0.14 U	NT	0.14 U
Calcium	0.62 U	NT	0.73 U	0.74 U	0.08 U	NT	0.04 U
Cadmium	784.0 (J)	NT	1,070.0 (J)	979.0 (J)	270.0 (J)	NT	1,120.0 J
Chromium	11.9	NT	12.0	10.8	8.0	NT	10.9
Cobalt	3.0 (J)	NT	3.3 (J)	4.1 (J)	4.5 (J)	NT	2.6 (J)
Copper	8.2	NT	10.4	11.4	2.0 (J)	NT	8.2
Iron	8,720.0	NT	10,100.0	9,270.0	7,880.0	NT	9,310.0
Lead	33.6	NT	80.0	89.6	8.2	NT	36.9
Magnesium	891.0 (J)	NT	878.0 (J)	861.0 (J)	347.0 (J)	NT	787.0 (J)
Manganese	143.0	NT	242.0	258.0	173.0	NT	136.0
Nickel	4.4 (J)	NT	4.8 (J)	6.6 (J)	3.6 U	NT	7.2 (JQ)
Potassium	345.0 (JQ)	NT	781.0 (J)	703.0 (J)	481.0 (J)	NT	433.0 (J)
Selenium	0.23 U	NT	0.34 (J)	0.26 U	0.28 U	NT	0.28 U
Sodium	79.9 (JQ)	NT	31.7 (JQ)	34.6 (JQ)	38.1 (JQ)	NT	27.1 (JQ)
Vanadium	13.1	NT	18.6	18.4	13.4	NT	18.1
Zinc	86.6 J	NT	91.9	83.4	12.5	NT	44.2

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BCM

IEA Organic Sample No.:	BCM17	BCM26	BCM01	BCM02	BCM03	BCM04	BCM09
IEA Inorganic Sample No.:	BCM11	..	BCM01	BCM02	BCM03	BCM04	..
BCM Sample No.:	000853	000862	000847	000846	000841	000842	000850
Sample Date:	12/18/89	12/19/89	12/13/89	12/13/89	12/14/89	12/14/89	12/15/89
Sample Name:	CSB-12	CSB-12	Field	Trip	Trip	Field	Trip
	(2-4)	(21.7-22)	Blank	Blank	Blank	Blank	Blank
Parameter (Units)							
Volatiles Organics (ug/kg)							
Acetone	11.0 U	10.0 U	2,800.0	10.0 U	10.0 U	15.0	10.0 U
Chloroform	8.0 U	5.0 U	120.0 U	5.0 U	5.0 U	5.0 U	5.0 U
Methylene Chloride	8.0 U	5.0 U	120.0 U	5.0 U	4.0 J	5.0 U	5.0 U
Trichloroethene	8.0 U	5.0 U	120.0 U	5.0 U	5.0 U	5.0 U	5.0 U
Total Volatiles	ND	ND	2,800.0	ND	4.0	15.0	ND
Volatiles Organic Tentatively Identified Compounds (ug/kg)							
Hexane	ND	ND	ND	ND	ND	30.0 J	ND
Pentane, 2-methyl-	ND	ND	ND	ND	ND	ND	ND
Pentane, 3-methyl-	ND	ND	ND	ND	ND	8.0 J	ND
Silanol, trimethyl-	ND	ND	ND	ND	ND	ND	ND
Unknown (Total)	ND	ND	ND	ND	ND	14.0	ND
Unknown Hydrocarbon	ND	ND	ND	ND	ND	ND	ND
Total Volatile TICs	ND	ND	ND	ND	ND	52.0	ND
Semivolatiles Organics (ug/kg)							
Benzoic Acid	1,800.0 U	NT	50.0 U	NT	NT	50.0 U	NT
bis(2-Ethylhexyl) phthalate	370.0 U	NT	8.0 J	NT	NT	10.0	NT
Isothrene	370.0 U	NT	10.0 U	NT	NT	10.0 U	NT
Total Semivolatiles	ND	NT	8.0	NT	NT	10.0	NT
Semivolatiles Organic Tentatively Identified Compounds (ug/kg)							
1-Hexanol, 2-ethyl-	300.0 J	NT	ND	NT	NT	ND	NT
DDE isomer (27.86)	ND	NT	ND	NT	NT	ND	NT
Hexachloro acid, diethyl ester (29.27)	8,000.0 BJ	NT	ND	NT	NT	ND	NT
Methanamine (15.66)	ND	NT	ND	NT	NT	ND	NT
Substituted Phenol (Total)	200.0	NT	10.0	NT	NT	10.0	NT
Trichloropropene isomer (10.42)	ND	NT	ND	NT	NT	ND	NT
Unknown (Total)	1,500.0 B	NT	10.0	NT	NT	8.0	NT
Unknown Aromatic (35.27)	ND	NT	ND	NT	NT	ND	NT
Unknown Chloroacarbon (13.38)	ND	NT	ND	NT	NT	ND	NT
Unknown Acid	ND	NT	ND	NT	NT	ND	NT
Unknown Hydrocarbon (8.45)	ND	NT	10.0 J	NT	NT	ND	NT
Unknown Ketone (Total)	ND	NT	ND	NT	NT	ND	NT
Total Semivolatiles TICs	10,000.0	NT	30.0	NT	NT	18.0	NT
Pesticides (ug/kg)							
4,4'-DDE	14.0 J	NT	0.1 U	NT	NT	0.10 U	NT
4,4'-DDD	18.0 U	NT	0.1 U	NT	NT	0.10 U	NT
4,4'-DDT	18.0 U	NT	0.1 U	NT	NT	0.10 U	NT
Inorganic Compounds (mg/kg)							
Aluminum	8,800.0	NT	71.2 U	71.2 U	71.2 U	71.2 U	NT
Arsenic	1.8 (J)	NT	1.0 U	1.0 U	1.0 U	1.0 U	NT
Barium	28.8 (J)	NT	1.7 U	1.7 U	1.7 U	1.7 U	NT
Beryllium	0.18 U	NT	0.7 U	0.7 U	0.7 U	0.7 U	NT
Cadmium	0.87 U	NT	3.2 U	3.2 U	3.2 U	3.2 U	NT
Calcium	908.0 (J)	NT	41.7 (J)	8.2 U	8.2 U	44.8 (J)	NT
Chromium	7.4	NT	4.1 U	4.1 U	4.1 U	4.1 U	NT
Cobalt	9.0 (J)	NT	10.7 U	10.7 U	10.7 U	10.7 U	NT
Copper	3.3 (J)	NT	3.9 U	3.9 U	3.9 U	3.9 U	NT
Iron	9,080.0	NT	131.0	8.1 (J)	12.8 (J)	88.8 (J)	NT
Lead	8.7	NT	1.0 U	1.0 U	1.0 U	1.0 U	NT
Magnesium	380.0 (J)	NT	4.4 U	4.4 U	4.4 U	4.4 U	NT
Manganese	136.0	NT	4.0 U	4.0 U	4.0 U	4.0 U	NT
Nickel	3.7 U	NT	18.6 (J)	18.0 U	18.0 U	18.0 U	NT
Potassium	404.0 (J)	NT	1,100.0 (J)	874.0 U	1,030.0 (J)	897.0 (J)	NT
Selenium	0.23 U	NT	1.2 U	1.2 U	1.2 U	1.2 U	NT
Sodium	18.2 U	NT	183.0 (J)	77.8 U	84.3 (J)	186.0 (J)	NT
Vanadium	14.8	NT	8.1 U	8.1 U	8.1 U	8.1 U	NT
Zinc	14.8	NT	12.3 (J)	4.1 (J)	10.8 (J)	17.3 (J)	NT

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IEA Organic Sample No.:	BCM10	BCM13	BCM14	BCM18	BCM19	BCM23	BCM24
IEA Inorganic Sample No.:	..	BCM09	BCM14	BCM12	BCM13
BCM Sample No.:	000851	000853	000854	000858	000860	000863	000864
Sample Date:	12/18/89	12/18/89	12/18/89	12/18/89	12/18/89	12/20/89	12/20/89
Sample Name:	Field	Field	Trip	Trip	Field	Trip	Field
	Blank	Blank	Blank	Blank	Blank	Blank	Blank
Parameter (Units)							
<u>Volatile Organics (ug/lb)</u>							
Acetone	10.0 U	10.0 U	10.0 U	10.0 U	10.0 U	10.0 U	10.0 U
Chloroform	5.0 U	4.0 BJQ	7.0 BQ	5.0 U	5.0 U	5.0 U	5.0 U
Methylene Chloride	5.0 U	5.0 U	5.0 U	5.0 U	5.0 U	5.0 U	5.0 U
Trichloroethene	5.0 U	5.0 U	5.0 U	5.0 U	5.0 U	5.0 U	5.0 U
Total Volatiles	ND	ND	ND	ND	ND	ND	ND
<u>Volatile Organic Tentatively Identified Compounds (ug/lb)</u>							
Hexane	20.0 J	20.0 J	ND	ND	60.0 J	ND	9.0 J
Pentane, 2-methyl-	ND	ND	ND	ND	10.0 J	ND	ND
Pentane, 3-methyl-	ND	ND	ND	ND	20.0 J	ND	ND
Silanol, trimethyl-	ND	ND	ND	ND	ND	ND	ND
Unknown (Total)	ND	ND	ND	ND	ND	ND	ND
Unknown Hydrocarbon	ND	ND	ND	ND	20.0 J	ND	ND
Total Volatile TICs	20.0	20.0	ND	ND	110.0	ND	9.0
<u>Semivolatile Organics (ug/lb)</u>							
Benzene Acid	NT	50.0 U	NT	NT	50.0 U	NT	NT
bis(2-Ethylhexyl) phthalate	NT	10.0 U	NT	NT	10.0 U	NT	NT
Isophorene	NT	10.0 U	NT	NT	10.0 U	NT	NT
Total Semivolatiles	NT	ND	NT	NT	ND	NT	NT
<u>Semivolatile Organic Tentatively Identified Compounds (ug/lb)</u>							
1-Hexanol, 2-ethyl-	NT	ND	NT	NT	ND	NT	NT
DDE isomer (27.85)	NT	ND	NT	NT	ND	NT	NT
Heptadecanoic acid, diethyl ester (29.37)	NT	ND	NT	NT	ND	NT	NT
Methanamine (18.86)	NT	100.0 J	NT	NT	ND	NT	NT
Substituted Phenol (Total)	NT	100.0 J	NT	NT	ND	NT	NT
Trichloropropene isomer (10.43)	NT	10.0 J	NT	NT	ND	NT	NT
Unknown (Total)	NT	228.0	NT	NT	110.0	NT	NT
Unknown Aromatic (28.37)	NT	ND	NT	NT	ND	NT	NT
Unknown Chlorocarbon (13.38)	NT	10.0 BJ	NT	NT	ND	NT	NT
Unknown Acid	NT	ND	NT	NT	ND	NT	NT
Unknown Hydrocarbon (8.45)	NT	ND	NT	NT	ND	NT	NT
Unknown Ketone (Total)	NT	ND	NT	NT	ND	NT	NT
Total Semivolatile TICs	NT	348.0	NT	NT	110.0	NT	NT
<u>Pesticides (ug/lb)</u>							
4,4'-DDE	NT	0.10 U	NT	NT	0.10 U	NT	NT
4,4'-DDD	NT	0.10 U	NT	NT	0.10 U	NT	NT
4,4'-DDT	NT	0.10 U	NT	NT	0.10 U	NT	NT
<u>Inorganic Compounds (mg/lb)</u>							
Aluminum	NT	71.2 U	NT	71.2 U	71.2 U	NT	NT
Arsenic	NT	1.0 U	NT	1.0 U	1.0 U	NT	NT
Barium	NT	2.1 [I]	NT	1.7 U	1.7 [I]	NT	NT
Beryllium	NT	0.7 U	NT	0.7 U	0.7 U	NT	NT
Cadmium	NT	3.2 U	NT	3.2 U	3.2 U	NT	NT
Calcium	NT	128.0 [I]	NT	137.0 [I]	208.0 [I]	NT	NT
Chromium	NT	4.1 U	NT	4.1 U	4.1 U	NT	NT
Cobalt	NT	10.7 U	NT	10.7 U	10.7 U	NT	NT
Copper	NT	3.9 U	NT	3.9 U	3.9 U	NT	NT
Iron	NT	29.1 [IQ]	NT	15.9 [IQ]	22.8 [IQ]	NT	NT
Lead	NT	1.0 U	NT	1.0 U	1.0 U	NT	NT
Magnesium	NT	4.4 U	NT	4.4 U	4.4 U	NT	NT
Manganese	NT	4.0 U	NT	4.0 U	4.0 U	NT	NT
Nickel	NT	21.0 [I]	NT	18.0 U	18.0 U	NT	NT
Potassium	NT	674.0 U	NT	781.0 [IQ]	674.0 U	NT	NT
Selenium	NT	1.2 U	NT	1.2 U	1.2 U	NT	NT
Sodium	NT	644.0 [I]	NT	473.0 [I]	778.0 [I]	NT	NT
Vanadium	NT	8.1 U	NT	8.1 U	8.1 U	NT	NT
Zinc	NT	4.0 U	NT	4.0 U	7.8 [I]	NT	NT

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BCM

IEA Organic Sample No.:	BCM31	BCM32	BCM34	BCM35	BCM40	BCM41
IEA Inorganic Sample No.:	BCM31	BCM32	BCM34	BCM35	BCM40	BCM41
BCM Sample No.:	004999	005000	005298	005270	006796	006797
Sample Date:	02/22/90	02/22/90	02/26/90	02/26/90	02/27/90	02/27/90
Sample Name:	Trip	Field	Trip	Field	Field	Trip
Parameter (Units)	Blank *	Blank *	Blank *	Blank *	Blank *	Blank *
Volatile Organics (ug/lb)						
Acetone	10.0 U	10.0 U	10.0 U	10.0 U	10.0 U	10.0 U
Chloroform	5.0 U	5.0 U	5.0 U	5.0 U	5.0 U	5.0 U
Methylene Chloride	5.0 U	5.0 U	5.0 U	5.0 U	5.0 U	5.0 U
Trichloroethylene	5.0 U	5.0 U	5.0 U	5.0 U	5.0 U	5.0 U
Total Volatiles	ND	ND	ND	ND	ND	ND
Volatile Organic Tentatively Identified Compounds (ug/lb)						
Hexane	ND	ND	ND	ND	ND	ND
Pentane, 2-methyl-	ND	ND	ND	ND	ND	ND
Pentane, 3-methyl-	ND	ND	ND	ND	ND	ND
Silanol, trimethyl-	ND	ND	ND	ND	ND	ND
Unknown (Total)	ND	ND	ND	ND	ND	ND
Unknown Hydrocarbon	ND	ND	ND	ND	ND	ND
Total Volatile TICs	ND	ND	ND	ND	ND	ND
Semivolatile Organics (ug/lb)						
Benzole Acid	NT	50.0 U	NT	NT	50.0 U	NT
bis(2-Ethylhexyl) phthalate	NT	10.0 U	NT	NT	10.0 U	NT
Nonaphene	NT	10.0 U	NT	NT	10.0 U	NT
Total Semivolatile	NT	ND	NT	NT	ND	NT
Semivolatile Organic Tentatively Identified Compounds (ug/lb)						
1-Hexanol, 2-methyl-	NT	ND	NT	NT	ND	NT
DDE Isomer (87.45)	NT	ND	NT	NT	ND	NT
Hexachloro acid, diethyl ee (38.37)	NT	ND	NT	NT	ND	NT
Methoxyamine (18.86)	NT	ND	NT	NT	ND	NT
Substituted Phenol (Total)	NT	10.0	NT	NT	ND	NT
Trichloropropene Isomer (10.42)	NT	ND	NT	NT	ND	NT
Unknown (Total)	NT	5.0	NT	NT	ND	NT
Unknown Aromatic (38.37)	NT	ND	NT	NT	ND	NT
Unknown Hydrocarbon (13.38)	NT	ND	NT	NT	ND	NT
Unknown Acid	NT	ND	NT	NT	ND	NT
Unknown Hydrocarbon (8.45)	NT	ND	NT	NT	ND	NT
Unknown Ketone (Total)	NT	ND	NT	NT	ND	NT
Total Semivolatile TICs	NT	15.0	NT	NT	NT	NT
Pesticides (ug/lb)						
4,4'-DDE	NT	0.10 U	NT	NT	0.10 U	NT
4,4'-DDD	NT	0.10 U	NT	NT	0.10 U	NT
4,4'-DDT	NT	0.10 U	NT	NT	0.10 U	NT
Inorganic Compounds (mg/lb)						
Aluminum	71.2 U	71.2 U	NT	NT	71.2 U	71.2 U
Arsenic	1.0 U	1.0 U	NT	NT	1.0 U	1.0 U
Barium	1.6 [J]	3.7 [J]	NT	NT	2.2 [J]	1.7 U
Beryllium	0.7 U	0.7 U	NT	NT	0.87 [J]	0.7 U
Cadmium	3.2 U	3.2 U	NT	NT	3.2 U	3.2 U
Calcium	80.4 [J]	187.0 [J]	NT	NT	221.0 [J]	68.6 [J]
Chromium	4.1 U	4.1 U	NT	NT	4.1 U	4.1 U
Cobalt	10.7 U	10.7 U	NT	NT	10.7 U	10.7 U
Copper	3.9 U	3.9 U	NT	NT	3.9 U	3.9 U
Iron	9.2 [J]	15.8 [J]	NT	NT	4.7 [J]	5.1 [J]
Lead	1.0 U	1.0 U	NT	NT	1.0 U	1.0 U
Magnesium	4.4 U	4.4 U	NT	NT	4.4 U	4.4 U
Manganese	4.0 U	4.0 U	NT	NT	4.0 U	4.0 U
Nickel	24.8 [J]	18.0 U	NT	NT	18.0 U	18.0 U
Potassium	674.0 U	680.0 [J]	NT	NT	710.0 [J]	674.0 U
Selenium	1.2 U	1.2 U	NT	NT	1.2 U	1.2 U
Sodium	351.0 [J]	492.0 [J]	NT	NT	520.0 [J]	298.0 [J]
Vanadium	8.1 U	8.1 U	NT	NT	8.1 U	8.1 U
Zinc	4.0 U	4.4 [J]	NT	NT	5.8 [J]	6.8 [J]

J Estimated value
 B Analyte detected in associated laboratory blank
 U Analyte undetected at the instrument detection (IDL); value reported is the contract required detection limit (CROL)
 [J] Bracketed value; concentration is less than the CROL but greater than the IDL
 O Not questioned due to blank contamination
 * Sample C38-7 (20.5-30.5) obtained 12/14/88, but shipped 12/15/88; sample C38-12 (21.7-22) obtained 12/19/88, but shipped 12/20/88
 ** Field duplicate samples
 *** Trip and field blanks reported in ug/l
 ND Not detected
 NT Not tested
 IEA Industrial & Environmental Analysis, Inc.
 Source: BCM Engineers Inc. (Project No. 00-8018-02)

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TABLE 4-3

SUMMARY OF SOIL ANALYTICAL RESULTS
EPA SPLIT SAMPLESCHEM-SOLV, INC SITE REMEDIAL INVESTIGATION
CHESWOLD, DELAWARE

EPA Organic Sample No.:	CCH16	CCH17	CCH17	CCH56	CCH18	CCH59
Sample Date:	02/22/90	02/22/90	02/27/90	02/27/90	02/22/90	02/22/90
EPA Sample Name:	S901-01	S901-02	S903-02	S903-04	SW001	SW002
Sample Location:	C5B-8 0.5-2'	C5B-8 0.5-2'	C5B-10 2-4'	C5B-10 18-18.5'	Trip Blank	Trip Blank
Parameter (Units)						
<u>Volatile Organics (ug/kg)</u>						
Acetone	32.0 B	80.0 B	13.0 B	27.0 B	10.0 UJ	13.0 B
Chlorobenzene	1.0 J	8.0 UJ	8.0 UL	8.0 UL	5.0 U	5.0 U
Chloroform	6.0 U	6.0 U	6.0 U	6.0 U	4.0 J	4.0 J
1,2-Dichloroethene (Total)	6.0 U	6.0 U	6.0 U	6.0 U	3.0 B	5.0 U
Methylene Chloride	30.0 B	26.0 B	25.0 B	22.0 B	3.0 B	5.0 B
Toluene	3.0 J	6.0 UJ	6.0 UL	6.0 UL	5.0 U	5.0 U
Total Xylenes	6.0 UJ	6.0 UJ	8.0 UL	9.0 UL	3.0 J	5.0 U
Trichloroethene	3.0 J	4.0 J	6.0 U	6.0 U	5.0 U	5.0 U
Total Volatiles	7.0	4.0	ND	ND	7.0	4.0
<u>Volatile Organics Tentatively Identified Compounds (ug/kg)</u>						
Hexane	ND	ND	ND	7.0 J	ND	ND
<u>Semivolatile Organics (ug/kg)</u>						
Di-(2-Ethylhexyl) phthalate	240.0 J	210.0 J	280.0 J	NT	NT	NT
Di-n-octylphthalate	740.0 U	170.0 J	800.0 U	NT	NT	NT
Isohexane	740.0 U	740.0 U	1,800.0	NT	NT	NT
Total Semivolatiles	240.0	380.0	2,180.0	NT	NT	NT
<u>Semivolatile Organics Tentatively Identified Compounds (ug/kg)</u>						
Unknown	400.0 J	500.0 J	400.0 J	NT	NT	NT
Unknown Alkane (Total)	ND	ND	1,800.0 J	NT	NT	NT
Total Semivolatile TICs	400.0	500.0	2,200.0	NT	NT	NT
<u>Pesticides (ug/kg)</u>						
4,4'-DDE	110.0	100.0	210.0	NT	NT	NT
4,4'-DDD	36.0 U	36.0 U	32.0 J	NT	NT	NT
4,4'-DDT	57.0 J	56.0 J	33.0 J	NT	NT	NT
Total Pesticides	167.0	156.0	275.0	NT	NT	NT
<u>Inorganic Compounds (mg/kg)</u>						
Aluminum	12,800.0	13,800.0	10,800.0	NT	NT	NT
Arsenic	7.7	6.8	5.4	NT	NT	NT
Barium	75.8	71.4	58.4	NT	NT	NT
Cadmium	0.2 (J)		0.5 (J)	NT	NT	NT
Calcium	717.0 (J)	671.0 (J)	1,800.0 (J)	NT	NT	NT
Chromium	11.8	12.4	17.5	NT	NT	NT
Cobalt	6.0 (J)	5.7 (J)	6.0 (J)	NT	NT	NT
Copper	10.8	10.0	11.7	NT	NT	NT
Iron	9,370.0	9,720.0	6,370.0	NT	NT	NT
Lead	33.8	28.0	48.8	NT	NT	NT
Magnesium	771.0 (J)	778.0 (J)	782.0 (J)	NT	NT	NT
Manganese	284.0	230.0	146.0	NT	NT	NT
Nickel	8.8 (J)	8.1 (J)	8.6 (J)	NT	NT	NT
Potassium	441.0 (J)	443.0 (J)	502.0 (J)	NT	NT	NT
Sodium	80.4 (J)	64.3 (J)	61.8 (J)	NT	NT	NT
Vanadium	18.0	19.3	17.8	NT	NT	NT
Zinc	44.1	41.2	154.0	NT	NT	NT

B Not detected substantially above the level reported in laboratory or field blanks.

J Analyte present. Reported value may not be accurate or precise.

ND Not detected

NT Not tested

U Not detected. The associated number indicates approximate carbon concentration necessary to be detected.

UJ Not detected; quantitation limit may be inaccurate or imprecise.

UL Not detected; quantitation limit is probably higher.

(J) Analyte present. As values approach the instrument detection limit, the quantitation may not be accurate.

Source: U.S. EPA Region III

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TABLE 4-4
BACKGROUND SOIL LEVELS FOR INORGANIC COMPOUNDS
HEM-SOLV, INC. SITE REMEDIATION INVESTIGATION
CHESWOLD, DELAWARE

Parameter (mg/kg)	Northern Delaware (a)	Delaware (b)		Southern NJ/ Maryland/ Delaware (e)	Eastern U.S. Geometric Mean (d)
		Mean	SD		
Aluminum	30,000	—	—	700 - 30,000	—
Arsenic	<0.1 - 2.8	—	—	19 - 41 ^a	—
Barium	500	—	—	10 - 300	300
Beryllium	<1	—	—	<1	—
Cadmium	—	0.17	0.06	—	1.8 ^c
Calcium	130 - 2,300	—	—	130 - 5,200	—
Chromium	50	—	—	1 - 30	36
Cobalt	3 - 5	—	—	<3	7
Copper	<1 - 10	5	2.2	<1 - 20	14
Iron	<7,000	—	—	100 - 10,000	15,000
Lead	20	10	2	<10 - 20	14
Magnesium	0 - 1,500	—	—	50 - 3,000	—
Manganese	150	—	—	<2 - 300	285
Nickel	7 - 10	6.6	4.4	<5 - 10	13
Potassium	16,000	—	—	2,200 - 11,000	—
Selenium	0.5	—	—	<0.1 - 0.3	—
Sodium	0 - 5,000	—	—	<500 - 5,000	—
Vanadium	30 - 50	—	—	<7 - 50	48
Zinc	82 ^c	25	9	<5 - 198 ^c	36

SD Standard Deviation

— Data not available

- ^a Shacklette & Boerngen, 1984. Element Concentrations in Soils and other Surficial Materials of the Conterminous United States.
- ^b Logan, T.G. and Ryan, J.A., 1987. Land Application of Sludge, Lewis Publishers, Chelsea, MI.
- ^c Pennsylvania State University, 1985. Criteria and Recommendations for Land Applications of Sludges in the Northeast. Bulletin 851, March 1985.
- ^d USEPA, 1985. Water Quality Assessment: A Screening Procedure for Toxic and Conventional Pollutants in Surface and Ground Water - Part 1. EPA/600/5-85/002a. September 1985 Revised.
- ^e USEPA, 1984. Health Assessment Document for Inorganic Arsenic. EPA/600/5-83/021F. March 1984.

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TABLE 4-5
SUMMARY OF DIRECT GROUNDWATER ANALYTICAL RESULTS
FROM THROUGHPUT MAY 1990
CHEN-SOLV, INC. SITE REMEDIAL INVESTIGATION
CHESHOLD, DELAWARE

Parameter (Units)	Lab ID: 3777 Sample Date: 10/03/94 Sample Name: CB-1A	3777 01/02/95 CB-3A	3780 01/02/95 CB-4A	3781 02/19/95 CB-5A	4543 12/05/94 CB-5A	4545 12/05/94 CB-7A	4546 12/05/94 CB-8A	4548 12/05/94 Simon	4549 12/05/94 Harris	4550 12/05/94 Williams	4551 12/05/94 Gossney	4578 12/05/94 CB-9A	4579 12/05/94 CB-9B	4580 12/05/94 CB-1A
Volatiles Organics (mg/L)	5.1	210.0	ND	22.0	110.0	ND	ND	ND	ND	ND	ND	ND	ND	1,800.0
1,1,1-Trichloroethane	ND	ND	ND	1.4	7.0	ND	ND	ND	ND	ND	ND	ND	ND	ND
1,1,2-Trichloroethane	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Chlorobenzene	150.0	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	150.0
Benzene	230.0	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	230.0
M-xylene	27.0	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	27.0
O-xylene	<16.0	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	111.0
P-xylene	680.0	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	334.0
Toluene	800.0	500.0	ND	250.0	770.0	8.2	ND	ND	ND	ND	ND	ND	ND	310,000.0
Trichloroethylene	1,742.1	710.0	ND	274.4	887.0	8,400.2	ND	ND	ND	ND	ND	ND	ND	2.6
Total Volatiles														112,730.0

Lab ID:	4581	4582	355	357	358	361	362	363	364	365	382	1163	1164	1165
Sample Date:	12/05/94	12/05/94	01/29/95	01/29/95	01/29/95	01/29/95	01/29/95	01/29/95	01/29/95	01/29/95	01/29/95	04/22/95	04/22/95	04/22/95
Sample Name:	CB-6A	CB-3A	CB-5A	CB-2A	CB-3A	CB-4B	CB-7A	CB-7B	CB-8A	CB-4B	CB-1A	CB-7A	CB-7B	CB-8A

Parameter (Units)

Volatiles Organics (mg/L)	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
1,1,1-Trichloroethane	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
1,1,2-Trichloroethane	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Chlorobenzene	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Benzene	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
M-xylene	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
O-xylene	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
P-xylene	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Toluene	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Trichloroethylene	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Total Volatiles	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND

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Table 4.5 (Continued)

Sample Name	1967 01/22/85 CB-5A	1968 01/22/85 CB-5B	1969 04/22/85 CB-4B	1172 04/22/85 Simon	1172 04/22/85 CB-2A	1183 04/22/85 CB-3A	1184 04/22/85 CB-4A	1185 04/22/85 CB-5A	1186 04/22/85 Cadenham	1187 04/22/85 Glenwood	1188 04/22/85 Harris	1189 04/22/85 Waters	1200 04/22/85 Lamberton	2570 04/14/85 CB-5A
Polycyclic Aromatic Hydrocarbons (PAHs)														
1,1,1-Trichloroethane	ND	2.1	ND	ND	180.0	3.1	78.0	1,300.0	ND	ND	ND	ND	ND	26.0
1,1,1,1-Tetrachloroethane	ND	—	—	—	6.4	—	ND	67.0	ND	ND	ND	ND	ND	—
1,1,2-Dichloroethane	ND	38.0	ND	ND	ND	ND	ND	ND	ND	2.9	ND	ND	ND	360.0
1,2-Dichloropropane	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Benzene	ND	1.3	ND	ND	ND	ND	ND	76.0	ND	ND	ND	ND	ND	—
Chlorobenzene	—	—	—	—	ND	ND	ND	25.0	ND	ND	ND	ND	ND	—
Ethylbenzene	—	—	—	—	ND	ND	ND	ND	ND	ND	ND	ND	ND	4.0
Toluene	—	—	—	—	ND	ND	ND	11.0	ND	ND	ND	ND	ND	—
trans-1,2-Dichloroethane	ND	2.2	ND	ND	12.5	18.0	430.0	1,800.0	ND	ND	ND	ND	ND	250.0
1,2-Dichloropropane	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Total Volatiles	ND	2.2	ND	ND	178.9	19.1	509.0	3,153.0	ND	2.9	ND	ND	ND	640.0

Lab ID:	2688	2687	2698	2700	2701	2703	2704	2705	2706	2707	2712	2713	2714
Sample Date:	08/22/85	08/22/85	08/22/85	08/22/85	08/22/85	08/22/85	08/22/85	08/22/85	08/22/85	08/22/85	08/25/85	08/25/85	08/25/85
Sample Name:	CB-14A	CB-10A	CB-11A	CB-12A	CB-13A	CB-5B	CB-15A	CB-16A	CB-18A	CB-17A	CB-8A	CB-8B	CB-7A

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Table 4-3 (Continued)

Parameter (Units)	2775 08/25/85 CB-7B	2776 08/25/85 CB-5B	2777 08/25/85 CB-5A	2778 08/25/85 CB-5B	2780 08/25/85 CB-4A	2781 08/25/85 CB-3A	2782 08/25/85 CB-2A	2783 08/25/85 CB-5A	2788 08/25/85 CB-5A 5 min.	2789 08/25/85 CB-5A 20 min.	2790 08/25/85 CB-5A 60 min.	2791 08/25/85 CB-5A 120 min.	2792 08/25/85 CB-5A 180 min.	2796 08/29/85 Williams Caserhart old
Metals Organics (mg/l)	ND	ND	ND	ND	33.0	32.0	195.0	12,500.0	10,500.0	10,600.0	9,500.0	10,500.0	12,000.0	-
1,1,1-Trichloroethane	ND	ND	ND	ND	ND	ND	8.1	ND	ND	ND	ND	ND	ND	-
1,1,2-Trichloroethane	ND	ND	ND	ND	4.1	ND	8.6	780.0	1,092.0	940.0	103.0	104.0	114.0	-
1,1,2,2-Tetrachloroethane	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	6.1
1,2-Dichloroethane	ND	ND	ND	ND	ND	ND	ND	280.0	280.0	160.0	260.0	176.0	180.0	-
Chloroform	ND	ND	ND	ND	ND	ND	ND	4.0	32.0	29.0	27.0	29.0	30.0	-
Ethylbenzene	ND	ND	ND	ND	ND	ND	ND	23.0	69.0	66.0	61.0	61.0	62.0	-
Toluene	ND	ND	ND	ND	ND	ND	4.4	180.0	120.0	130.0	120.0	150.0	160.0	-
Isomers 1,2-Dichlorobenzene	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Isomers 1,2-Dichlorobenzene	ND	ND	ND	ND	510.0	110.0	846.0	28,400.0	21,000.0	21,000.0	19,000.0	22,000.0	25,000.0	1.3
Trichlorobenzene	ND	ND	ND	ND	14.2	142.0	1,080.1	33,073.0	32,925.0	29,081.0	33,420.0	37,546.0	37,546.0	1.3
Total Volatiles	ND	ND	ND	ND	607.1	142.0	1,080.1	42,147.0	33,073.0	32,925.0	29,081.0	33,420.0	37,546.0	6.1

Lab ID: 2798
Sample Date: 08/29/85
Sample Name: Cole

Parameter (Units)

Metals Organics (mg/l)	2798 08/29/85 Durbien	2800 08/29/85 Johnson	2801 08/29/85 Harris	2802 08/29/85 Lambertson	2803 08/29/85 Savon	2805 08/29/85 Am. Reading	2807 09/12/85 CB-1A	2808 09/12/85 CB-1B	2809 09/12/85 CB-2A	2890 09/12/85 CB-2B	3306 10/04/85 CB-23A	3307 10/04/85 CB-23A	3308 10/04/85 CB-25A
Trichlorobenzene	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Total Volatiles	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Organic Compounds (mg/l)	-	-	-	-	-	-	-	-	-	-	-	-	-
Total Ben	-	-	-	-	-	-	ND	ND	ND	ND	-	-	-
Total Chlorobenzene	-	-	-	-	-	-	ND	ND	ND	ND	-	-	-
Manganese	-	-	-	-	-	-	10,600.0	9,280.0	8,800.0	8,800.0	-	-	-

Lab ID: 2800
Sample Date: 08/29/85
Sample Name: Johnson

Parameter (Units)

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Table 4.5 (Continued)

Parameter (Unit)	3300 10/04/85 CB-54A	3310 10/04/85 CB-55A	3311 10/04/85 CB-57A	3312 10/04/85 CB-58A	3313 10/04/85 CB-59A	3408 10/04/85 CB-53A	3409 10/04/85 CB-53AR	3817 10/24/85 CB-53AR	3818 10/24/85 CB-53AR	4020 11/26/85 Primary RAW	4021 11/26/85 Primary TR	116 01/02/86 Primary RAW	117 01/02/86 Primary TR
Metals (mg/L)													
1,1,1-Trichloroethane	ND	14.0	5.0	4.9	ND	ND	-	-	-	8,000.0	5.3	8,320.0	3.5
1,1,2-Trichloroethane	91.0	ND	ND	1.6	1.9	ND	-	-	-	76.0	ND	-	ND
1,1-Dichloroethane	4.8	4.0	ND	ND	ND	ND	-	-	-	10.0	ND	6.7	ND
1,2-Dichloroethane	ND	ND	ND	ND	ND	ND	-	-	-	6.0	ND	-	-
Benzene	ND	ND	ND	ND	144.0	ND	-	-	-	-	1.2	-	-
Bromobenzene	ND	ND	ND	ND	ND	ND	-	-	-	3.5	ND	337.0	ND
Chlorobenzene	ND	2.0	ND	ND	ND	ND	-	-	-	375.0	ND	-	ND
Chloroform	ND	ND	ND	ND	ND	ND	-	-	-	125.0	ND	-	ND
1,1,2,2-Tetrachloroethane	ND	ND	ND	ND	ND	ND	-	-	-	58.0	ND	-	ND
trans-1,2-Dichloroethane	ND	9.0	ND	ND	ND	ND	-	-	-	305.0	7.3	-	ND
trans-1,3-Dichloroethane	128.0	389.0	197.0	207.0	2.4	ND	-	-	-	865.0	ND	2,283.0	ND
Trichloroethylene	128.0	400.0	197.0	207.0	2.4	ND	-	-	-	34,200.0	29.1	27,008.0	ND
Total Volatiles													
Organic Compounds (mg/L)													
Total Ion	-	-	-	-	-	-	-	0.36	0.16	-	-	-	-
Total Chlorinated Ion	-	-	-	-	-	-	-	ND	ND	-	-	-	-
Benzenes	-	-	-	-	-	-	-	6.1	5.86	-	-	-	-
Other Parameters													
pH (25°C, Unsat)	-	-	-	-	-	6.4	6.4	-	-	-	-	-	-
Alkalinity (mg/L)	-	-	-	-	-	82.0	80.0	-	-	-	-	-	-
Hardness (mg/L)	-	-	-	-	-	150.0	124.0	198.0	116.0	-	-	-	-
Acidity (mg/L)	-	-	-	-	-	-	-	79.0	55.0	-	-	-	-

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Table 4.5 (Continued)

Lab ID:	646	647	H357	H358	H380	H381	H382	H383	H384	H385	H385	H385	H386	H387
Sample Date:	01/02/86	01/02/86	02/19/86	02/19/86	02/19/86	02/19/86	02/19/86	02/19/86	02/19/86	02/19/86	02/19/86	02/19/86	02/19/86	02/19/86
Sample Name:	Recovery	Recovery	Johnson	Durham	Klein	Phillips	Lambertson	Semon	Williams	American	Food	Cutley	Gaumnert - New	Coe
Parameter (Units)	ppm	TR											Old	
Volatiles Organic (mg/L)	86.0	NO	-	-	-	-	0.5	-	-	0.1	-	-	-	-
1,1,1-Trichloroethane	143.0	NO	-	-	-	-	-	-	-	-	-	-	-	-
1,1-Dichloroethane	-	-	-	-	-	-	-	-	-	-	-	-	-	-
1,2-Dichloroethane	91.0	NO	-	-	-	-	-	-	-	-	-	-	-	-
Isopropyl Alcohol	2,353.0	0.3	0.3	NO	NO	NO	0.1	NO	NO	-	-	0.6	-	0.5
Technical Grade	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Total Volatiles	2,672.0	0.3	0.3	NO	NO	NO	0.6	NO	NO	0.1	0.1	0.6	31.0	0.5

Lab ID:	H388	768	767	768	769	770	771	772	773	774	775	775	777	778
Sample Date:	02/19/86	03/11/86	03/11/86	03/11/86	03/11/86	03/11/86	03/11/86	03/11/86	03/11/86	03/11/86	03/11/86	03/11/86	03/11/86	03/11/86
Sample Name:	Metric	OB-12A	OB-3A	OB-13A	OB-4A	OB-10A	OB-11A	OB-17A	OB-18A	OB-19A	Recovery	Recovery	OB-24A	OB-25A
Parameter (Units)														
Volatiles Organic (mg/L)	-	NO	1.5	NO	47.0	NO	182.0	NO	1.0	15.0	171.0	171.0	75.0	4.0
1,1,1-Trichloroethane	-	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
1,1-Dichloroethane	-	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
1,2-Dichloroethane	-	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
Isopropyl Alcohol	-	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
Technical Grade	-	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
Total Volatiles	NO	NO	4.0	NO	120.0	4.0	441.0	3.0	24.0	46.0	619.0	619.0	58.0	139.5

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○

Lab ID: _____
Sample Date: _____
Sample Name: _____

Partnership (Joint)

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Table 4.5 (Continued)

Parameter (Units)	2307 07/14/86 Qualitative Recovery TR	2308 07/14/86 Qualitative Recovery TR	2309 07/29/86 CB-37A	2310 07/29/86 CB-37A	2311 07/29/86 CB-37A	2312 07/29/86 CB-37A	2313 07/29/86 CB-37A	2314 07/29/86 CB-37A	2315 07/29/86 CB-37A	2316 07/29/86 CB-37A	2317 07/29/86 CB-37A	2318 07/29/86 CB-37A	2319 07/29/86 CB-37A
Metals Organics (µg/l)													
1,1,1-Trichloroethane	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
1,1-Dichloroethane	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
1,1-Dichloroethene	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
1,2-Dichloroethane	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Benzene	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Chloroform	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Toluene	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Isomers 1,2-Dichlorobenzene	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Trichloroethylene	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Total Volatiles	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND

Parameter (Units)	2320 07/29/86 CB-37A	2321 07/29/86 CB-37A	2322 07/29/86 CB-37A	2323 07/29/86 CB-37A	2324 07/29/86 CB-37A	2325 07/29/86 CB-37A	2326 07/29/86 CB-37A	2327 07/29/86 CB-37A	2328 07/29/86 CB-37A	2329 07/29/86 CB-37A	2330 07/29/86 CB-37A	2331 07/29/86 CB-37A	2332 07/29/86 CB-37A
Metals Organics (µg/l)													
1,1,1-Trichloroethane	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
1,1-Dichloroethane	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
1,1-Dichloroethene	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
1,2-Dichloroethane	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Benzene	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Chloroform	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Toluene	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Isomers 1,2-Dichlorobenzene	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Trichloroethylene	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Total Volatiles	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND

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Table 6.3 (Continued)

Parameter (Units)	4177	4179	4180	4181	4183	4184	4185	4186	4187	4188	4189	4203	4204	4205	4206
Lab ID:	11/18/86	11/18/86	11/18/86	11/18/86	11/18/86	11/18/86	11/18/86	11/18/86	11/18/86	11/18/86	11/18/86	11/18/86	11/18/86	11/18/86	11/18/86
Sample Date:	OB-38A	OB-38A	OB-37A	OB-36A	OB-5A-	OB-5A-	OB-5A-	OB-5A-	OB-5A-	OB-5A-	OB-5A-	OB-41A	OB-42A	OB-42A	OB-42A
Sample Name:															
Parameter (Units)															
Nitrobenzene	4.4	ND	1.4	ND	295.0	ND	2.0	2.0	3.8	5.5	2.9	ND	ND	ND	ND
1,1-Dichloroethane	3.1	1.4	ND	ND	28	1,152.0	ND	ND	ND	ND	ND	ND	ND	ND	ND
1,1-Dichloroethane	ND	ND	ND	ND	15.0	ND	ND	ND	1.0	ND	ND	ND	ND	ND	ND
1,2-Dichloroethane	1.3	7.4	ND	ND	ND	ND	ND	ND	30.0	ND	35.0	ND	ND	ND	ND
1,2-Dichloropropane	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Benzene	13.0	ND	ND	297.0	ND	ND	ND	ND	1.0	ND	1.0	ND	ND	ND	ND
Chloroform	1.1	ND	ND	ND	34.0	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Ethylbenzene	ND	ND	ND	5.6	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Toluene	ND	ND	ND	15.0	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Isopropylbenzene	1.5	1.5	ND	ND	15.0	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
1,2-Dichloroethane	23.0	123.0	74.0	ND	1,400.0	3.3	7.9	7.9	17.0	39.0	ND	7.3	1.0	ND	ND
1,2-Dichloroethane	23.0	123.0	74.0	ND	1,400.0	3.3	7.9	7.9	17.0	39.0	ND	7.3	1.0	ND	ND
Total Volatiles	258.4	133.7	75.4	305.6	1,763.8	1,155.3	9.9	9.9	52.8	44.5	35.9	39.3	1.0	ND	ND

Lab ID:	4207	4208	4209	4210	4211	4212	4213	4214	4215	4216	4217	4218	4219	4220	4221
Sample Date:	11/18/86	11/18/86	11/18/86	11/18/86	11/18/86	11/18/86	11/18/86	11/18/86	11/18/86	11/18/86	11/18/86	11/18/86	11/18/86	11/18/86	11/18/86
Sample Name:	OB-41A	OB-41A	OB-41A	OB-41A	OB-41A	OB-41A	OB-41A	OB-41A	OB-41A	OB-41A	OB-41A	OB-41A	OB-41A	OB-41A	OB-41A
Parameter (Units)															
Nitrobenzene	4.4	ND	1.4	ND	295.0	ND	2.0	2.0	3.8	5.5	2.9	ND	ND	ND	ND
1,1-Dichloroethane	3.1	1.4	ND	ND	28	1,152.0	ND	ND	ND	ND	ND	ND	ND	ND	ND
1,1-Dichloroethane	ND	ND	ND	ND	15.0	ND	ND	ND	1.0	ND	ND	ND	ND	ND	ND
1,2-Dichloroethane	1.3	7.4	ND	ND	ND	ND	ND	ND	30.0	ND	35.0	ND	ND	ND	ND
1,2-Dichloropropane	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Benzene	13.0	ND	ND	297.0	ND	ND	ND	ND	1.0	ND	1.0	ND	ND	ND	ND
Chloroform	1.1	ND	ND	ND	34.0	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Ethylbenzene	ND	ND	ND	5.6	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Toluene	ND	ND	ND	15.0	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Isopropylbenzene	1.5	1.5	ND	ND	15.0	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
1,2-Dichloroethane	23.0	123.0	74.0	ND	1,400.0	3.3	7.9	7.9	17.0	39.0	ND	7.3	1.0	ND	ND
1,2-Dichloroethane	23.0	123.0	74.0	ND	1,400.0	3.3	7.9	7.9	17.0	39.0	ND	7.3	1.0	ND	ND
Total Volatiles	258.4	133.7	75.4	305.6	1,763.8	1,155.3	9.9	9.9	52.8	44.5	35.9	39.3	1.0	ND	ND

Table 6.3 (Continued)

Lab ID:	4222	4223	4224	4225	4226	4227	4228	4229	4230	4231	4232	4233	4234	4235	4236
Sample Date:	11/18/86	11/18/86	11/18/86	11/18/86	11/18/86	11/18/86	11/18/86	11/18/86	11/18/86	11/18/86	11/18/86	11/18/86	11/18/86	11/18/86	11/18/86
Sample Name:	OB-41A	OB-41A	OB-41A	OB-41A	OB-41A	OB-41A	OB-41A	OB-41A	OB-41A	OB-41A	OB-41A	OB-41A	OB-41A	OB-41A	OB-41A
Parameter (Units)															
Nitrobenzene	4.4	ND	1.4	ND	295.0	ND	2.0	2.0	3.8	5.5	2.9	ND	ND	ND	ND
1,1-Dichloroethane	3.1	1.4	ND	ND	28	1,152.0	ND	ND	ND	ND	ND	ND	ND	ND	ND
1,1-Dichloroethane	ND	ND	ND	ND	15.0	ND	ND	ND	1.0	ND	ND	ND	ND	ND	ND
1,2-Dichloroethane	1.3	7.4	ND	ND	ND	ND	ND	ND	30.0	ND	35.0	ND	ND	ND	ND
1,2-Dichloropropane	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Benzene	13.0	ND	ND	297.0	ND	ND	ND	ND	1.0	ND	1.0	ND	ND	ND	ND
Chloroform	1.1	ND	ND	ND	34.0	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Ethylbenzene	ND	ND	ND	5.6	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Toluene	ND	ND	ND	15.0	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Isopropylbenzene	1.5	1.5	ND	ND	15.0	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
1,2-Dichloroethane	23.0	123.0	74.0	ND	1,400.0	3.3	7.9	7.9	17.0	39.0	ND	7.3	1.0	ND	ND
1,2-Dichloroethane	23.0	123.0	74.0	ND	1,400.0	3.3	7.9	7.9	17.0	39.0	ND	7.3	1.0	ND	ND
Total Volatiles	258.4	133.7	75.4	305.6	1,763.8	1,155.3	9.9	9.9	52.8	44.5	35.9	39.3	1.0	ND	ND

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Table 4-2 (Continued)

Parameter (Units)	Lab ID: 3443		3444		5270		5280		5290		5300		5310		5320		1213		1214		1215		1216		1217		1218	
	Sample Date: 9/28/88	Fielding	Sample Name: 3444	Fielding	Sample Date: 9/28/88	Fielding	Sample Name: 5270	Fielding	Sample Date: 9/28/88	Fielding	Sample Name: 5280	Fielding	Sample Date: 9/28/88	Fielding	Sample Name: 5290	Fielding	Sample Date: 9/28/88	Fielding	Sample Name: 5300	Fielding	Sample Date: 9/28/88	Fielding	Sample Name: 5310	Fielding	Sample Date: 9/28/88	Fielding	Sample Name: 5320	Fielding
Metals (mg/L)																												
Acetone	10.0		15.0		10.0		15.0		10.0		15.0		10.0		15.0		10.0		15.0		10.0		15.0		10.0		15.0	
Benzene	ND		ND		ND		ND		ND		ND		ND		ND		ND		ND		ND		ND		ND		ND	
Chloroform	23.0		23.0		23.0		23.0		23.0		23.0		23.0		23.0		23.0		23.0		23.0		23.0		23.0		23.0	
1,2-Dichloroethane	ND		ND		ND		ND		ND		ND		ND		ND		ND		ND		ND		ND		ND		ND	
Methylene Chloride	ND		ND		ND		ND		ND		ND		ND		ND		ND		ND		ND		ND		ND		ND	
Total Volatiles	33.0		45.0		33.0		45.0		33.0		45.0		33.0		45.0		33.0		45.0		33.0		45.0		33.0		45.0	

ND Not detected, detection limit not specified.
- Not reported, parameter may or may not have been analyzed for.

Source: Ciba-Geigy, Inc. March 1987

Compiled by: BCM Engineers Inc. (BCM Project No. 00-8015-02)

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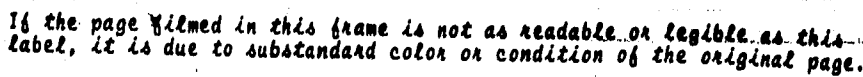


TABLE 4-6
SUMMARY OF GROUNDWATER ANALYTICAL RESULTS FOR ORGANIC COMPOUNDS
SHALLOW ZONE WELLS
APRIL 1990

CHEM-SOLV, INC. SITE REMEDIAL INVESTIGATION
CHESNOLD DELAWARE

[illegible]

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[illegible][illegible]

* Field duplicate samples
-- Most 26A was sampled for volatile organics April 5, 1990, and for semivolatile organics, pesticides/PCBs, and inorganics April 8, 1990
Presence of this compound questioned during data verification
U Analyte undetectable at field sampling detection limit (K1); value reported is the contact required detection limit (CRL)

☐ Please question the subject's consciousness

31

D

7. Discussion

5 **Guaranteed Investment**

THE UNIVERSITY OF CHICAGO

Source: BOM Engineers Inc., BOM Project No. 00-00

C

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5

1. **THE STATE OF TEXAS, County of _____, do hereby certify that _____, of the County of _____, State of _____, is the duly qualified and authorized representative of the _____, a corporation organized under the laws of the State of _____, and is authorized to execute and deliver the foregoing instrument, and to perform all acts and duties required of him in connection with the execution and delivery of the same.**



TABLE 4-7
SUMMARY OF GROUNDWATER ANALYTICAL RESULTS FOR INORGANIC COMPOUNDS
SHALLOW ZONE WELLS
APRIL 1990
CHEM-SOLV INC. SITE REMEDIAL INVESTIGATION
CHESAPEOTE, DELAWARE

[illegible]

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Table 47 (Continued)

EA Inorganic Sample No.:		BC 082	010573	010574	010575	010576	010577	010578	010579	010580	010581	010582	010583	010584	010585	010586	010587	010588	010589
BC Sample No.:		010573	010574	010575	010576	010577	010578	010579	010580	010581	010582	010583	010584	010585	010586	010587	010588	010589	010590
Sample Name:		010573	010574	010575	010576	010577	010578	010579	010580	010581	010582	010583	010584	010585	010586	010587	010588	010589	010590
Sample Number:		010573	010574	010575	010576	010577	010578	010579	010580	010581	010582	010583	010584	010585	010586	010587	010588	010589	010590
Well Type:		Unfiltered	Filtered	Unfiltered	Filtered	Unfiltered	Filtered	Unfiltered	Filtered	Unfiltered	Filtered	Unfiltered	Filtered	Unfiltered	Filtered	Unfiltered	Filtered	Unfiltered	Filtered
Parameter (Units)		Chloride (mg/L)	Chloride (mg/L)	Chloride (mg/L)	Chloride (mg/L)	Chloride (mg/L)	Chloride (mg/L)	Chloride (mg/L)	Chloride (mg/L)	Chloride (mg/L)	Chloride (mg/L)	Chloride (mg/L)	Chloride (mg/L)	Chloride (mg/L)	Chloride (mg/L)	Chloride (mg/L)	Chloride (mg/L)	Chloride (mg/L)	Chloride (mg/L)
Inorganic Components (mg/L)		7,500.0	7,500.0	7,500.0	7,500.0	7,500.0	7,500.0	7,500.0	7,500.0	7,500.0	7,500.0	7,500.0	7,500.0	7,500.0	7,500.0	7,500.0	7,500.0	7,500.0	7,500.0
Aluminum		12.0	12.0	12.0	12.0	12.0	12.0	12.0	12.0	12.0	12.0	12.0	12.0	12.0	12.0	12.0	12.0	12.0	12.0
Arctic		17.0	17.0	17.0	17.0	17.0	17.0	17.0	17.0	17.0	17.0	17.0	17.0	17.0	17.0	17.0	17.0	17.0	17.0
Boron		1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
Calcium		3.8	3.8	3.8	3.8	3.8	3.8	3.8	3.8	3.8	3.8	3.8	3.8	3.8	3.8	3.8	3.8	3.8	3.8
Chlorine		10,500.0	10,500.0	10,500.0	10,500.0	10,500.0	10,500.0	10,500.0	10,500.0	10,500.0	10,500.0	10,500.0	10,500.0	10,500.0	10,500.0	10,500.0	10,500.0	10,500.0	10,500.0
Chromium		27.1	27.1	27.1	27.1	27.1	27.1	27.1	27.1	27.1	27.1	27.1	27.1	27.1	27.1	27.1	27.1	27.1	27.1
Cobalt		12.8	12.8	12.8	12.8	12.8	12.8	12.8	12.8	12.8	12.8	12.8	12.8	12.8	12.8	12.8	12.8	12.8	12.8
Copper		6.8	6.8	6.8	6.8	6.8	6.8	6.8	6.8	6.8	6.8	6.8	6.8	6.8	6.8	6.8	6.8	6.8	6.8
Iron		20,800.0	20,800.0	20,800.0	20,800.0	20,800.0	20,800.0	20,800.0	20,800.0	20,800.0	20,800.0	20,800.0	20,800.0	20,800.0	20,800.0	20,800.0	20,800.0	20,800.0	20,800.0
Lead		4.8	4.8	4.8	4.8	4.8	4.8	4.8	4.8	4.8	4.8	4.8	4.8	4.8	4.8	4.8	4.8	4.8	4.8
Magnesium		11,100.0	11,100.0	11,100.0	11,100.0	11,100.0	11,100.0	11,100.0	11,100.0	11,100.0	11,100.0	11,100.0	11,100.0	11,100.0	11,100.0	11,100.0	11,100.0	11,100.0	11,100.0
Manganese		1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
Mercury		0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3
Nickel		8,000.0	8,000.0	8,000.0	8,000.0	8,000.0	8,000.0	8,000.0	8,000.0	8,000.0	8,000.0	8,000.0	8,000.0	8,000.0	8,000.0	8,000.0	8,000.0	8,000.0	8,000.0
Phosphorus		1.8	1.8	1.8	1.8	1.8	1.8	1.8	1.8	1.8	1.8	1.8	1.8	1.8	1.8	1.8	1.8	1.8	1.8
Selenium		8.0	8.0	8.0	8.0	8.0	8.0	8.0	8.0	8.0	8.0	8.0	8.0	8.0	8.0	8.0	8.0	8.0	8.0
Silver		34,000.0	34,000.0	34,000.0	34,000.0	34,000.0	34,000.0	34,000.0	34,000.0	34,000.0	34,000.0	34,000.0	34,000.0	34,000.0	34,000.0	34,000.0	34,000.0	34,000.0	34,000.0
Sulfur		19.8	19.8	19.8	19.8	19.8	19.8	19.8	19.8	19.8	19.8	19.8	19.8	19.8	19.8	19.8	19.8	19.8	19.8
Vanadium		100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
Zinc		63.3	63.3	63.3	63.3	63.3	63.3	63.3	63.3	63.3	63.3	63.3	63.3	63.3	63.3	63.3	63.3	63.3	63.3

Field duplicate samples
Result questioned due to blank contamination.
Analysis conducted at the treatment detection limit (IDL); values reported in the contract required detection limit (CIDL).
Background value; concentration is less than the CIDL but greater than the IDL.
BCM Engineers Inc. BCM Project No. 00-0012-00

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TABLE 4-9

SUMMARY OF GROUNDWATER ANALYTICAL RESULTS FOR INORGANIC COMPOUNDS
INTERMEDIATE ZONE WELLS
APRIL 1990CHEM-SOLV, INC. SITE REMEDIAL INVESTIGATION
CHESWOLD, DELAWARE

IEA Inorganic Sample No.: BCM Sample No.: Sample Date: Sample Name:	BC_066 010541 04/05/90 MW-1-43 Unfiltered Offsite UG	BC_046 D8C046 010579 04/04/90 Unfiltered Onsite DG	BC_058 D8C058 010564 04/05/90 Unfiltered Onsite SG	BC_059 D8C059 010566 04/05/90 Unfiltered Onsite SG	BC_060 D8C060 010569 04/05/90 Unfiltered Onsite DG	BC_064 D8C064 010567 04/05/90 Unfiltered Onsite DG
Parameter (Units)						
Inorganic Compounds (ug/l)						
Aluminum	71.9 U	71.9 U	428.0	398.0	71.9 U	1,430.0
Arsenic	1.2 U	1.2 U	1.2 U	1.2 U	1.2 U	1.2 U
Barium	135.0 U	125.0 U	97.6 U	96.8 U	125.0 U	171.0 U
Beryllium	0.3 U	0.3 U	0.3 U	0.3 U	0.3 U	0.7 U
Cadmium	3.8 U	3.8 U	3.8 U	3.8 U	3.8 U	3.8 U
Calcium	8,450.0	8,070.0	17,300.0	15,600.0	11,300.0	57,900.0
Chromium	6.4 U	6.4 U	6.4 U	6.4 U	6.4 U	6.4 U
Cobalt	12.6 U	12.6 U	12.6 U	12.6 U	12.6 U	12.6 U
Copper	10.1 U	6.8 U	6.8 U	6.8 U	6.8 U	6.8 U
Iron	17.3 U	9.4 U	724.0	768.0	716.0	1,060.0
Lead	1.0 U	1.0 U	3.4	2.3 U	1.0 U	1.0 U
Magnesium	2,300.0 U	2,250.0 U	8,210.0	7,300.0	4,040.0 U	5,050.0 U
Manganese	11.3 U	9.6 U	49.6	46.5	30.3	96.5
Mercury	0.4 U	0.4 U	2.9	2.8	0.2 U	0.4 U
Potassium	6,970.0	6,290.0	16,000.0	15,400.0	3,390.0 U	19,100.0
Selenium	1.2 U	1.4 U	1.5 U	1.2 U	1.2 U	1.9 U
Silver	8.0 U	8.0 U	8.0 U	8.0 U	8.0 U	8.0 U
Sodium	16,900.0	18,000.0	17,800.0	16,000.0	13,100.0	37,900.0
Vanadium	10.3 U	10.3 U	10.3 U	10.3 U	10.3 U	10.3 U
Zinc	49.6	34.5	25.6	28.4	37.0	70.9

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Table 4-9 (Continued)

IEA Inorganic Sample No.: BCM Sample No.: Sample Date: Sample Name:	BC 047 D8C047 010553 04/04/90 Field Blank	BC 048 010551 04/04/90 Trip Blank	BC 056 010552 04/05/90 Unfiltered	BC 058 D8C058 010553 04/05/90 Filtered	BC 057 010551 04/05/90 Trip Blank	BC 063 D8C063 010576 04/05/90 Unfiltered	BC 064 010574 04/05/90 Trip Blank	BC 068 D8C068 010546 04/09/90 Unfiltered	BC 069 D8C069 010545 04/09/90 Filtered	BC 070 D8C070 010544 04/09/90 Trip Blank
Parameter (Units)	Well Type:	Well Type:	Well Type:	Well Type:	Well Type:	Well Type:	Well Type:	Well Type:	Well Type:	Well Type:
Inorganic Compounds (µg/l)										
Aluminum	71.9 U	71.9 U	71.9 U	71.9 U	71.9 U	71.9 U	71.9 U	71.9 U	71.9 U	71.9 U
Antimony	12 U	12 U	12 U	12 U	12 U	12 U	12 U	12 U	12 U	12 U
Barium	2.1 U	2.1 U	2.1 U	2.1 U	2.1 U	2.1 U	2.1 U	2.1 U	2.1 U	2.1 U
Beryllium	1.6 U	1.6 U	1.6 U	1.6 U	1.6 U	1.6 U	1.6 U	1.6 U	1.6 U	1.6 U
Cadmium	3.8 U	3.8 U	3.8 U	3.8 U	3.8 U	3.8 U	3.8 U	3.8 U	3.8 U	3.8 U
Calcium	22.9 U	24.0 U	10.6 U	25.2 U	29.2 U	9.8 U	9.8 U	25.4 U	22.2 U	10.5 U
Chromium	6.4 U	6.4 U	6.4 U	6.4 U	6.4 U	6.4 U	6.4 U	6.4 U	6.4 U	6.4 U
Cobalt	12.6 U	15.2 U	12.6 U	15.3 U	12.6 U	12.6 U	12.6 U	12.6 U	12.6 U	12.6 U
Copper	6.8 U	6.8 U	6.8 U	6.8 U	6.8 U	6.8 U	6.8 U	6.8 U	6.8 U	6.8 U
Iron	32.0 U	17.1 U	6.2 U	74.3 U	9.4 U	6.2 U	6.2 U	6.2 U	6.2 U	6.2 U
Lead	1.0 U	1.0 U	1.0 U	1.0 U	1.0 U	1.0 U	1.0 U	1.0 U	1.0 U	1.0 U
Magnesium	2.6 U	7.0 U	2.6 U	9.2 U	3.7 U	2.0 U	2.0 U	13.0 U	11.0 U	3.7 U
Manganese	2.8 U	2.8 U	2.8 U	2.8 U	2.8 U	2.8 U	2.8 U	2.8 U	2.8 U	2.8 U
Mercury	0.2 U	0.4 U	0.4 U	0.2 U	0.2 U	0.2 U	0.2 U	0.2 U	0.2 U	0.2 U
Potassium	950.0 U	1,050.0 U	843.0 U	1,130.0 U	843.0 U	843.0 U	843.0 U	843.0 U	843.0 U	843.0 U
Selenium	12 U	12 U	12 U	12 U	12 U	12 U	12 U	12 U	12 U	12 U
Silver	8.0 U	8.0 U	8.0 U	8.0 U	8.0 U	8.0 U	8.0 U	8.0 U	8.0 U	8.0 U
Sodium	680.0 U	755.0 U	777.0 U	200.0 U	53.2 U	799.0 U	53.2 U	924.0 U	967.0 U	53.2 U
Vanadium	10.3 U	10.3 U	10.3 U	10.3 U	10.3 U	10.3 U	10.3 U	10.3 U	10.3 U	10.3 U
Zinc	5.7 U	6.5 U	11.5 U	5.0 U	11.8 U	5.0 U	5.0 U	14.3 U	10.3 U	5.0 U

- Field duplicate sample
- Analyte associated with the instrument detection (IDL); value reported is the contract required detection limit (CRDL)
- Brackets: value; concentration is less than the CRDL, but greater than the DL
- DG Downgrade
- SG Side grade
- UG Upgrade (background)
- IEA Industrial and Environmental Analysis, Inc.

Source: BCM Engineers Inc. (BCM Project No. 00-8012-02)

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TABLE 4-10

SUMMARY OF GROUNDWATER ANALYTICAL RESULTS FOR ORGANIC COMPOUNDS
EPA SPLIT SAMPLES
APRIL 1990CHEM-SOLV, INC SITE REMEDIAL INVESTIGATION
CHESWOLD, DELAWARE

EPA Organic Sample No.:	CX699	CX732	CX697	CX696	CX695
Sample Date:	04/06/90	04/06/90	04/05/90	04/05/90	04/05/90
Sample Name:	SB*	SBC*	41A	MWS-6-18	Tri6 Blank
Well Type:	Onsite Int. SG	Onsite Int. SG	Offsite Sh. DG	Offsite Sh. DG	
Parameter (Units)					
<u>Volatile Organics (ug/l)</u>					
2-Butanone	10.0 R	10.0 R	10.0 R	10.0 R	10.0 R
Chloroform	5.0 U	5.0 U	5.0 U	2.0 J	5.0 U
Methylene Chloride	3.0 B	6.0 B	5.0 B	1.0 B	6.0 B
Total Volatiles	ND	ND	ND	2.0	ND
<u>Semivolatile Organics (ug/l)</u>					
	ND	ND	ND	ND	NT
<u>Semivolatile Organic Tentatively Identified Compounds (ug/l)</u>					
2-Cyclohexen-ol	ND	ND	10 J	ND	NT
Unknown (Total)	ND	ND	38 J	ND	NT
<u>Pesticides/PCBs (ug/l)</u>					
	ND	ND	ND	ND	NT

- * Field duplicate samples
- B Not detected substantially above the level reported in laboratory or field blanks.
- J Analyte present. Reported value may not be accurate or precise.
- R Unreliable result. Analyte may or may not be present in the sample. Supporting data necessary to confirm result.
- U Not detected. The associated number indicates approximate sample concentration necessary to be detected.
- ND Not detected
- NT Not tested
- DG Downgradient
- SG Side gradient

Source: U.S. EPA Region III
Compiled by: BCM Engineers Inc. (BCM Project No. 00-8012-02)

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TABLE 4-11
SUMMARY OF GROUNDWATER ANALYTICAL RESULTS FOR INORGANIC COMPOUNDS
EPA SPLIT SAMPLES
APRIL 1990
CHEM-SOLV, INC. SITE REMEDIAL INVESTIGATION
CHESWOLD, DELAWARE

EPA Inorganic Sample No.: Sample Date: Sample Name: Well Type:	MCC005 04/05/90 Unfiltered Onsite Intermediate SG	MCC006 04/05/90 Unfiltered Onsite Intermediate SG	MCC007 04/05/90 Unfiltered Onsite Intermediate SG	MCC008 04/05/90 Unfiltered Onsite Intermediate SG	MCC009 04/05/90 Unfiltered Onsite Intermediate SG	MCC010 04/05/90 Unfiltered Onsite Shallow DG	MCC011 04/05/90 Unfiltered Onsite Shallow DG	MCC012 04/05/90 Unfiltered Onsite Shallow DG	MCC013 04/05/90 Unfiltered Onsite Shallow DG	MCC014 04/05/90 Unfiltered Onsite Shallow DG	MCC015 04/05/90 Unfiltered Onsite Shallow DG
Parameter (Units)											
Inorganic Compounds (ug/l)											
Aluminum	114.0 U	14.0 U	227.0	14.0 U	93.0 U	64.0 U	20,400.0	14.0 U	14.0 U	14.0 U	14.0 U
Antimony	33.0 U	47.0 U	38.0 U	48.0 U	44.0 B	32.0 U	53.0 U	49.0 U	49.0 U	49.0 U	26.0 U
Barium	88.0 U	86.0 U	86.0 U	93.0 U	42.0 U	45.0 U	171.0 U	280.0	9.0 U	9.0 U	9.0 U
Calcium	16,100.0	15,900.0	15,800.0	16,200.0	25,900.0	24,800.0	11,400.0	7,190.0	127.0 U	101.0 U	101.0 U
Chromium	4.0 U	4.0 U	4.0 U	4.0 U	4.0 U	4.0 U	63.0	4.0 U	4.0 U	4.0 U	4.0 U
Cobalt	4.0 U	4.0 U	4.0 U	4.0 U	5.0 U	4.0 U	14.0 U	4.0 U	4.0 U	4.0 U	4.0 U
Copper	3.0 U	3.0 U	3.0 U	3.0 U	3.0 U	3.0 U	17.0 U	3.0 U	3.0 U	3.0 U	3.0 U
Iron	260.0	60.0 U	464.0	35.0 U	903.0	950.0 U	61,300.0	49.0 U	49.0 U	49.0 U	49.0 U
Lead	7.0	10.0 B	7.0 K	61.0 B	2.0 U	12.0 B	29.0	5.0 B	2.0 U	15.0 K	15.0 K
Magnesium	7,730.0	7,690.0	7,660.0	7,790.0	12,400.0	12,000.0	3,850.0 U	1,930.0 U	30.0 U	30.0 U	30.0 U
Manganese	47.0	45.0	47.0	45.0	1,890.0	1,840.0	702.0	151.0	3.0 U	3.0 U	3.0 U
Mercury	1.8	1.9	1.4	2.2	0.2 U	0.2 U	0.2 U	0.2 U	0.2 U	0.2 U	0.2 U
Potassium	16,500.0	16,500.0	16,600.0	16,900.0	4,710.0	4,570.0 U	5,900.0	4,350.0 U	90.0 U	90.0 U	90.0 U
Selenium	4.0 U	4.0 U	4.0 U	4.0 U	6.0	4.0 U	4.0 U	4.0 U	4.0 U	4.0 U	4.0 U
Sodium	16,700.0	16,600.0	16,600.0	16,900.0	83,100.0	80,200.0	86,100.0	80,700.0	303.0 U	200.0 U	200.0 U
Vanadium	4.0 U	4.0 U	4.0 U	4.0 U	4.0 U	4.0 U	60.0	4.0 U	4.0 U	4.0 U	4.0 U
Zinc	21.0 B	17.0 U	17.0 U	20.0 B	7.0 U	7.0 U	65.0	58.0	11.0 U	11.0 U	11.0 U

duplicate samples
[] Analyte present. As values approach the instrument detection limit (IDL) the quantitation may not be accurate.
B Not detected substantially above the level reported in laboratory or field blanks.
K Analyte present. Reported value may be biased high. Actual value is expected to be lower.
U Not detected. The associated number indicates approximate sample concentration necessary to be detected.
UL Not detected; quantitation limit is probably higher.
DG Downgradient
SG Side gradient

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TABLE 4-12
SUMMARY OF GROUNDWATER ANALYTICAL RESULTS FOR VOLATILE ORGANIC COMPOUNDS AND MISCELLANEOUS PARAMETERS
FEBRUARY 1991
HEM-SOLV, INC. SITE REMEDIAL INVESTIGATION
HESWOLD, DELAWARE

EA Organic Sample No.: EA Sample No.: ECM Sample No.: Sample Date: Sample Name: Well Type:	BC045	8650078	8650071	8650073	8650074	8650085	8650084	8650075	8650082	BC002	BC006
EA Organic Sample No.:	010577	02/20/91	02/20/91	02/20/91	02/20/91	02/21/91	02/21/91	02/20/91	02/21/91	02/19/91	02/19/91
EA Sample No.:	5A	5B	9A**	9A0**	9B	16A	19A	22A	24A	26A	33A**
ECM Sample No.:	Onsite DG	Onsite DG	Onsite SG	Onsite SG	Onsite SG	Onsite DG	Onsite SG	Onsite UG	Onsite DG	Onsite DG	Onsite DG
Sample Date:	Shallow	Intermediate	Shallow	Shallow	Intermediate	Shallow	Shallow	Shallow	Shallow	Shallow	Shallow
Sample Name:	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT
Well Type:	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT
Parameter (Units)	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT
Volatiles Organics (ug/l)	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT
Benzene	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT
1,1,1-Trichloroethane	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT
Tetrachloroethene	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT
Trichloroethene	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT
Tentatively Identified	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT
Volatiles Organics (ug/l)	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT
Butane, 2-methyl-	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT
Unknown	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT
Pentane, 3-methyl-	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT
Cyclopentane, methyl-	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT
Unknown Hydrocarbon	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT
Unknown	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT
Cyclohexane, methyl-	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT
Unknown Hydrocarbon	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT
Pentane, 2,3-dimethyl-	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT
Hexane, 2,3-dimethyl-	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT
Other Parameters	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT
BOD (mg/l)	2.0 U	2.0 U	2.0 U	2.0 U	2.0 U	2.0 U	2.0 U	2.0 U	2.0 U	2.0 U	2.0 U
COD (mg/l)	25 U	25 U	25 U	25 U	25 U	25 U	25 U	25 U	25 U	25 U	25 U
Ammonia (as N) (mg/l)	0.01 U	0.01 U	0.01 U	0.01 U	0.01 U	0.01 U	0.01 U	0.01 U	0.01 U	0.01 U	0.01 U
Chloride (mg/l)	3.0	2.0	1.5	1.5	1.5	1.2	1.0	1.0	1.0	1.0	1.0
Sulfate (mg/l)	0.81	3.9	0.02 U	0.02 U	0.02 U	0.02 U	0.02 U	0.02 U	0.02 U	0.02 U	0.02 U
Sulfide (mg/l)	50	22	39	38	48	23	39	24	68	46	46
Dissolved oxygen (ppm)	1.0 U	1.0 U	1.0 U	1.0 U	1.0 U	1.0 U	1.0 U	1.0 U	1.0 U	1.0 U	1.0 U
Before purging	7.0	5.8 [8.2]	4.9 *	4.9 *	3.8 *	2.1	1.6	1.4	1.6	1.6	1.6
After purging	7.3	7.7 [8.4]	4.2	4.2	2.0	2.2	1.6	1.6	1.6	1.6	1.6
pH (nat. units)	4.90	4.47	5.81	5.81	4.56	5.63	5.50	4.67	5.82	5.59	5.59
Spec. cond. (umhos/cm)	135	103	255	255	260	205	195	167	203	238	238
Temperature (C)	13.5	14	15	15	15.5	13.5	13.5	14	14	14	14

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Table 4-12 (Continued)

EA Organic Sample No.:	NA	SC004	NA	NA	NA	SC004	NA	NA	NA	NA	NA	NA
EA Sample No.:	6800072	6800072	6800072	6800072	6800072	6800072	6800072	6800072	6800072	6800072	6800072	6800072
EA Sample No.:	111785	111785	111785	111785	111785	111785	111785	111785	111785	111785	111785	111785
Sample Date:	02/19/91	02/19/91	02/19/91	02/19/91	02/19/91	02/19/91	02/19/91	02/19/91	02/19/91	02/19/91	02/19/91	02/19/91
Sample Name:	3BA	3BA	3BA	3BA	3BA	3BA	3BA	3BA	3BA	3BA	3BA	3BA
Well Type:	Shallow	Shallow	Shallow	Shallow	Shallow	Shallow	Shallow	Shallow	Shallow	Shallow	Shallow	Shallow
Parameter (Units)	Shallow	Shallow	Shallow	Shallow	Shallow	Shallow	Shallow	Shallow	Shallow	Shallow	Shallow	Shallow
Weight Organic (mg)												
Dioxane	5 U	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT
1,1,1-Trichloroethane	8	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT
Trichloroethene	5 U	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT
Trichloroethane	110	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT
Technical Identified												
Weight Organic (mg)												
Benzene	ND	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT
Benzene, 2-methyl-	ND	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT
Pentane, 3-methyl-	ND	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT
Cyclohexane, methyl-	ND	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT
Unknown Hydrocarbon	ND	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT
Unknown	ND	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT
Cyclohexane, methyl-	ND	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT
Unknown Hydrocarbon	ND	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT
Pentane, 2,3,3-trimethyl-	ND	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT
Hexane, 2,3-dimethyl-	ND	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT
Hexane, 2,3-dimethyl-4-ethyl-	ND	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT
Other Parameters												
CO ₂ (mg/L)	2.0 U	2.0 U	NT	2.0 U	NT	2.0 U	NT	2.0 U	NT	2.0 U	NT	2.0 U
CO ₂ (mg/L)	25 U	25 U	NT	25 U	NT	25 U	NT	25 U	NT	25 U	NT	25 U
Acetone (mg/L)	0.01 U	0.2	NT	0.01 U	NT	0.01 U	NT	0.01 U	NT	0.01 U	NT	0.01 U
Chloride (mg/L)	14	150	NT	8.0	NT	17	NT	1.0 U	NT	1.0 U	NT	1.0 U
Nitrate (mg/L)	7.4	0.35	NT	NT	8.6	9.4	0.02 U	0.02 U	NT	0.02 U	NT	0.02 U
Nitrite (mg/L)	0.02 U	0.05	NT	NT	0.02 U	0.02 U	0.02 U	0.02 U	NT	0.02 U	NT	0.02 U
Sulfate (mg/L)	43	3.0 U	NT	26	NT	37	3.0 U	3.0 U	NT	3.0 U	NT	3.0 U
Sulfide (mg/L)	1.2	1.0 U	NT	1.0 U	NT	1.0 U	NT	1.0 U	NT	1.0 U	NT	1.0 U
Disinfectant (ppm)												
Before purging	11.2	[1.2]	NT	NT	[5.6]	NT	NT	NT	NT	NT	NT	NT
After purging	[3.0]	[3.5]	NT	NT	4.0	4.0	NT	NT	NT	NT	NT	NT
pH (unitless)	5.38	5.71	4.81	4.83	RT	132	NT	NT	NT	NT	NT	NT
Sp. Cond. (micro/cm)	238	480	730	137	NT	132	NT	NT	NT	NT	NT	NT
Temperature (°C)	14	15	14.5	14	NT	14.5	NT	NT	NT	NT	NT	NT
Notes												
1. Sample number for test chemistry analyses												
2. For duplicate samples												
3. Samples obtained 02/21/91 for white and white analyses												
4. All samples were submitted on the chain-of-custody form and is actually an equipment blank												
5. For a value of 5.0 was obtained at approx. 23.8; For 80 a value of 4.0 was obtained at approx. 25.9.												
6. For a value of 5.0 was obtained at approx. 23.8; For 80 a value of 4.0 was obtained at approx. 25.9.												
7. For a value of 5.0 was obtained at approx. 23.8; For 80 a value of 4.0 was obtained at approx. 25.9.												
8. For a value of 5.0 was obtained at approx. 23.8; For 80 a value of 4.0 was obtained at approx. 25.9.												
9. For a value of 5.0 was obtained at approx. 23.8; For 80 a value of 4.0 was obtained at approx. 25.9.												
10. For a value of 5.0 was obtained at approx. 23.8; For 80 a value of 4.0 was obtained at approx. 25.9.												
11. For a value of 5.0 was obtained at approx. 23.8; For 80 a value of 4.0 was obtained at approx. 25.9.												
12. For a value of 5.0 was obtained at approx. 23.8; For 80 a value of 4.0 was obtained at approx. 25.9.												
13. For a value of 5.0 was obtained at approx. 23.8; For 80 a value of 4.0 was obtained at approx. 25.9.												
14. For a value of 5.0 was obtained at approx. 23.8; For 80 a value of 4.0 was obtained at approx. 25.9.												
15. For a value of 5.0 was obtained at approx. 23.8; For 80 a value of 4.0 was obtained at approx. 25.9.												
16. For a value of 5.0 was obtained at approx. 23.8; For 80 a value of 4.0 was obtained at approx. 25.9.												
17. For a value of 5.0 was obtained at approx. 23.8; For 80 a value of 4.0 was obtained at approx. 25.9.												
18. For a value of 5.0 was obtained at approx. 23.8; For 80 a value of 4.0 was obtained at approx. 25.9.												
19. For a value of 5.0 was obtained at approx. 23.8; For 80 a value of 4.0 was obtained at approx. 25.9.												
20. For a value of 5.0 was obtained at approx. 23.8; For 80 a value of 4.0 was obtained at approx. 25.9.												
21. For a value of 5.0 was obtained at approx. 23.8; For 80 a value of 4.0 was obtained at approx. 25.9.												
22. For a value of 5.0 was obtained at approx. 23.8; For 80 a value of 4.0 was obtained at approx. 25.9.												
23. For a value of 5.0 was obtained at approx. 23.8; For 80 a value of 4.0 was obtained at approx. 25.9.												
24. For a value of 5.0 was obtained at approx. 23.8; For 80 a value of 4.0 was obtained at approx. 25.9.												
25. For a value of 5.0 was obtained at approx. 23.8; For 80 a value of 4.0 was obtained at approx. 25.9.												
26. For a value of 5.0 was obtained at approx. 23.8; For 80 a value of 4.0 was obtained at approx. 25.9.												
27. For a value of 5.0 was obtained at approx. 23.8; For 80 a value of 4.0 was obtained at approx. 25.9.												
28. For a value of 5.0 was obtained at approx. 23.8; For 80 a value of 4.0 was obtained at approx. 25.9.												
29. For a value of 5.0 was obtained at approx. 23.8; For 80 a value of 4.0 was obtained at approx. 25.9.												
30. For a value of 5.0 was obtained at approx. 23.8; For 80 a value of 4.0 was obtained at approx. 25.9.												
31. For a value of 5.0 was obtained at approx. 23.8; For 80 a value of 4.0 was obtained at approx. 25.9.												
32. For a value of 5.0 was obtained at approx. 23.8; For 80 a value of 4.0 was obtained at approx. 25.9.												
33. For a value of 5.0 was obtained at approx. 23.8; For 80 a value of 4.0 was obtained at approx. 25.9.												
34. For a value of 5.0 was obtained at approx. 23.8; For 80 a value of 4.0 was obtained at approx. 25.9.												
35. For a value of 5.0 was obtained at approx. 23.8; For 80 a value of 4.0 was obtained at approx. 25.9.												
36. For a value of 5.0 was obtained at approx. 23.8; For 80 a value of 4.0 was obtained at approx. 25.9.												
37. For a value of 5.0 was obtained at approx. 23.8; For 80 a value of 4.0 was obtained at approx. 25.9.												
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TABLE 4-13
SUMMARY OF GROUNDWATER ANALYTICAL RESULTS FOR INORGANIC COMPOUNDS
FEBRUARY 1991
CHEM-SOLV, INC. SITE REMEDIAL INVESTIGATION
CHESHOLD, DELAWARE

Parameter (Units)	Well Type:	BC 001	BC 002	BC 003	BC 004	BC 005	BC 006	BC 007	BC 008	BC 009	BC 010	BC 005	BC 005	SC 027
EA Inorganic Sample No.:		BC 021	BC 002	BC 003	BC 004	BC 005	BC 006	BC 007	BC 008	BC 009	BC 010	BC 005	BC 005	SC 027
EA Inorganic Sample No.:		0111781	0111782	0111783	0111784	0111785	0111786	0111787	0111788	0111789	0111790	0111791	0111792	0111793
BCMA Sample No.:		0111781	0111782	0111783	0111784	0111785	0111786	0111787	0111788	0111789	0111790	0111791	0111792	0111793
Sample Date:		02/19/91	02/19/91	02/19/91	02/19/91	02/19/91	02/19/91	02/19/91	02/19/91	02/19/91	02/19/91	02/19/91	02/19/91	02/20/91
Sample Name:		Blank	Blank	Blank	Blank	Blank	Blank	Blank	Blank	Blank	Blank	Blank	Blank	Blank
Well Type:		Shallow	Shallow	Shallow	Shallow	Shallow	Shallow	Shallow	Shallow	Shallow	Shallow	Shallow	Shallow	Shallow

Inorganic Compounds (mg/l)	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT
Mercury	0.20 U	0.20 U	0.20 U	0.20 U	0.20 U	0.20 U	0.20 U	0.20 U	0.20 U	0.20 U	0.20 U	0.20 U	0.20 U	0.20 U
Mercury (inorganic)	0.20 U	0.20 U	0.20 U	0.20 U	0.20 U	0.20 U	0.20 U	0.20 U	0.20 U	0.20 U	0.20 U	0.20 U	0.20 U	0.20 U
Zinc	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT

• IEA Sample No. for samples analyzed for inorganic mercury.
• Duplicate samples
• Not detected substantially above the level reported in laboratory or field blanks
• Value exceeds instrument calibration range
• Value exceeds instrument detection limit (IDL); value reported is the contract required detection limit (CRDL).
• Analyte undetectable at the instrument detection limit (IDL); value reported is the contract required detection limit (CRDL).
NT Not tested
U Unfiltered
DG Degraded
SG Shallow
EA Equipment
SC Sample
BCMA Blank
IEA Inorganic
Source: BCM Engineering, Inc. BCM Project No. 00-6012-02

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TABLE 4-14

SUMMARY OF GROUNDWATER ANALYTICAL RESULTS
EPA SPLIT SAMPLES
FEBRUARY 1991

CHEM-SOLVING SITE REMEDIAL INVESTIGATION
CHESNOLD, DELAWARE

Parameter (Units)	910221-07 02/19/91 300" Unfiltered Chloro DG Shallow	910221-08 02/19/91 300" Unfiltered Chloro DG Shallow	910221-09 02/19/91 300" Unfiltered Chloro DG Shallow	910221-010 02/19/91 No Blank Unfiltered	910221-11 02/19/91 Lab Blank Unfiltered	910221-01 02/20/91 Unfiltered Chloro SG Intermediate	910221-02 02/20/91 Filtered Chloro SG Intermediate	910221-03 02/20/91 Unfiltered Chloro SG Intermediate	910221-04 02/20/91 Filtered Chloro SG Intermediate	910221-05 02/20/91 Unfiltered Field Blank	910221-06 02/20/91 Filtered Field Blank
1,1,1-Trichloroethane	U	11.6	11.6	U	U	NT	NT	NT	NT	NT	NT
1,1,2-Trichloroethane	U	U	U	U	U	NT	NT	NT	NT	NT	NT
1,2-Dichloroethane	0.4 J	U	U	U	U	NT	NT	NT	NT	NT	NT
2,2,4,4-Tetrachloroethane	3.4 B	U	U	2.4 J	U	NT	NT	NT	NT	NT	NT
Acetone	U	U	U	8.3 J	U	NT	NT	NT	NT	NT	NT
Benzene	32.0	U	U	0.4 J	U	NT	NT	NT	NT	NT	NT
Bromochloroethane	U	U	U	U	U	NT	NT	NT	NT	NT	NT
Chloroform	U	1.4 B	1.3 B	5.2	U	NT	NT	NT	NT	NT	NT
cis-1,2-Dichloroethane	U	1.4 J	1.5 J	6.0 J	U	NT	NT	NT	NT	NT	NT
Isopropylchloride	15.9	U	U	U	U	NT	NT	NT	NT	NT	NT
m & p-Xylene Isomers	9.4 J	U	U	U	U	NT	NT	NT	NT	NT	NT
Methylene Chloride	6.2	U	U	U	U	NT	NT	NT	NT	NT	NT
n-Butylchloride	8.8	U	U	U	U	NT	NT	NT	NT	NT	NT
n-Propylchloride	1.3 J	U	U	U	U	NT	NT	NT	NT	NT	NT
tert-Butylchloride	1.3 J	U	U	U	U	NT	NT	NT	NT	NT	NT
Toluene	U	142	142	U	U	NT	NT	NT	NT	NT	NT
Trichloroethene	U	U	U	U	U	NT	NT	NT	NT	NT	NT
Trichloroethylene	U	U	U	U	U	NT	NT	NT	NT	NT	NT
Xylene (m & p Isomers)	0.4 J	U	U	U	U	NT	NT	NT	NT	NT	NT
Volatiles (Group 1)	U	U	U	U	U	NT	NT	NT	NT	NT	NT
Chlorobenzene	10.0 J	NO	NO	NO	NO	NT	NT	NT	NT	NT	NT
1,2-Dichlorobenzene	33.9 J	NO	NO	NO	NO	NT	NT	NT	NT	NT	NT
1,4-Dichlorobenzene	17.0 J	NO	NO	NO	NO	NT	NT	NT	NT	NT	NT
1,1-Dichloro-2,2-bis(4-chlorophenyl)ethane	20.9 J	NO	NO	NO	NO	NT	NT	NT	NT	NT	NT
Benzene, 1-methyl-2-(1-methylpropyl)-	180 J	NO	NO	NO	NO	NT	NT	NT	NT	NT	NT
Benzene, 2-methyl-	20.0 J	NO	NO	NO	NO	NT	NT	NT	NT	NT	NT
Benzene, 2,3-dimethyl-	94.0 J	NO	NO	NO	NO	NT	NT	NT	NT	NT	NT
Cyclohexane, 1-methyl-	NO	NO	NO	NO	NO	NT	NT	NT	NT	NT	NT
Nonahal (BTEX)	NO	NO	NO	NO	NO	NT	NT	NT	NT	NT	NT

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Table 4-14 (Continued)

EPA Sample No.: Sample Date: Sample Name:		910221-07 02/19/91 0807 Unfiltered Crude DO Shallow	910221-08 02/19/91 0807 Unfiltered Crude DO Shallow	910221-09 02/19/91 0807 Unfiltered Crude DO Shallow	910221-010 02/19/91 0807 Unfiltered Crude DO Shallow	910221-11 02/19/91 0807 Unfiltered Crude DO Shallow	910221-01 02/20/91 0807 Unfiltered Crude SG Intermediate	910221-03 02/20/91 0807 Unfiltered Crude SG Intermediate	910221-04 02/20/91 0807 Unfiltered Crude SG Intermediate	910221-05 02/20/91 0807 Unfiltered Crude SG Intermediate	910221-06 02/20/91 0807 Unfiltered Crude SG Intermediate
Volatile Organic Compounds (VOCs)											
Chlorinated Compounds (CCs)											
Perchloroethylene (PCE)		31.0 J	ND	ND	ND	ND	NT	NT	NT	NT	NT
Perchloroethane (PCAE)		24.0 J	ND	ND	ND	ND	NT	NT	NT	NT	NT
Trichloroethylene (TCE)		12.0 J	ND	ND	ND	ND	NT	NT	NT	NT	NT
Trichloroethane (TCAE)		4.5 J	ND	ND	ND	ND	NT	NT	NT	NT	NT
Dichloroethylene (DCE)		61.0 J	ND	ND	ND	ND	NT	NT	NT	NT	NT
Dichloroethane (DCAE)		88.0 J	ND	ND	ND	ND	NT	NT	NT	NT	NT
Monochloroethylene (MCE)		28.0 J	ND	ND	ND	ND	NT	NT	NT	NT	NT
Monochloroethane (MCAE)		22.0 J	ND	ND	ND	ND	NT	NT	NT	NT	NT
Ethylene (E)		2.0 J	ND	ND	ND	ND	NT	NT	NT	NT	NT
Propane (P)		6.0 J	ND	ND	ND	ND	NT	NT	NT	NT	NT
Isopentane (IP)		NT	NT	NT	NT	NT	1.7	1.6	1.8	<0.2	<0.2
Methane (M)		NT	NT	NT	NT	NT	2.6	2.5	2.2	<0.2	<0.2
Other Parameters (OPs)											
Biochemical oxygen demand (BOD)		NT	NT	NT	NT	NT	<1.0 *	<1.0	NT	1.5	NT
Chemical oxygen demand (COD)		NT	NT	NT	NT	NT	13.2 *	13.4	NT	34.8	NT
Total suspended solids (TSS)		NT	NT	NT	NT	NT	<0.040 *	<0.040	NT	<0.040	NT
Chloride (CL)		NT	NT	NT	NT	NT	13.5	13.2	NT	<0.2	NT
Nitrate (NO3)		NT	NT	NT	NT	NT	9.82	9.81	NT	<0.2	NT
Nitrite (NO2)		NT	NT	NT	NT	NT	<0.08	NT	NT	<0.05	NT
Sulfate (SO4)		NT	NT	NT	NT	NT	51.3	50	NT	<0.5	NT
Substrate		NT	NT	NT	NT	NT	<0.2 *	<0.2	NT	<0.2	NT

* Values are in parentheses. Both results are below detection limit or are negative.

NT = Not tested; ND = Not detected; J = Jug; S = Sample; F = Filtered; U = Unfiltered; C = Crude; SG = Surface Groundwater; I = Intermediate; S = Shallow; D = Deep.

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Source: U.S. Environmental Protection Agency, Region III

Contract: BCM Engineers Inc. (BCM) Project No. 90-013-03

Date: 03/07/91

Page: 13



TABLE 4-15

SUMMARY OF GROUNDWATER ANALYTICAL RESULTS
DNREC RESULTS
MARCH 1991CHEM-SOLV, INC SITE REMEDIAL INVESTIGATION
CHESWOLD, DELAWARE

EPA Organic Sample No.:	606	607	608	609	610
Sample Date:	03/04/91	03/04/91	03/04/91	03/04/91	03/04/91
Sample Name:	Simon Well	Amer. Roofing	Gearhart/Shane	35A	Trip Blank
Well Type:	Domestic SG	Domestic DG	Domestic DG	Offsite DG	Shallow
Parameter (Units)					
<u>Volatile Organics (ug/l)</u>					
Acetone	9 JB	6 JB	13 B	6 JB	8 JB
Benzene	5 U	5 U	5 U	12	5 U
2-Butanone	16 B	14 B	16 B	15 B	15 B
1,1-Dichloroethane	5 U	5 U	5 U	2 J	5 U
1,2-Dichloroethane	5 U	5 J	5 U	5 J	5 U
1,1,1-Trichloroethane	5 U	5 U	5 U	3 J	5 U
<u>Volatile Organic Tentatively Identified Compounds (ug/l)</u>					
1H-Indene, 2,3-dihydro-1-met	ND	ND	ND	28 JN	ND
Unknown	ND	ND	ND	7 JN	ND
Unknown	ND	ND	ND	6 JN	ND
<u>Inorganic Compounds (ug/l)</u>					
Manganese	27.5 E	67 E	212 E	NT	2 UE
Mercury	0.2 U	0.2 U	0.2 U	NT	0.2 U
Zinc	118	171	21.0	NT	1.5 S

- B Not detected substantially above the level reported in laboratory or field blanks.
E Value exceeds instrument calibration range
J Analyte present. Reported value may not be accurate or precise.
U Not detected. The associated number indicates approximate sample concentration necessary to be detected.
N Compound not present in calibration file.
ND Not detected
NT Not tested
DG Downgradient
SG Sidegradient
Note: all samples unfiltered

Source: Delaware Department of Natural Resources and Environmental Control
Compiled by: BCM Engineers Inc. (BCM Project No. 00-8012-02)

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SECTION 5.0

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5.0 HUMAN HEALTH AND ENVIRONMENTAL RISK ASSESSMENT

5.1 INTRODUCTION

5.1.1 Overview

This human health and environmental risk assessment describes the potential for adverse health effects from exposure to chemicals found in the soil and groundwater at the site. Risk assessment combines the concentration of the chemicals with toxicological data to produce a numerical estimate of the potential health effects due to current or future possible exposure to chemicals.

5.1.2 Site Description

This section presents a brief description of the site and a summary of the conditions pertinent to the risk assessment. For the risk assessment, the points of interest in the site description focus on opportunities for human and environmental exposure, now and in the future. The site description includes surrounding land use, evidence for current exposure, and the site's proximity to surface waters. A more detailed presentation of this information is given in Sections 3.1 and 3.2 of this report.

The 1.5-acre Chem-Solv site is an open field adjacent to a four-lane highway. The surrounding land use is a medium-density mixture of agricultural, commercial, and residential land use. Although there is a residential unit adjacent to the site and there are others in the area, area residents have left no evidence of consistent site use such as dirt bike paths or pathways to schools or playgrounds crossing the site.

The solvent recovery facility, which operated from 1982 to 1984, was closed after an explosion and fire that may have released solvents into the surrounding soil, groundwater, and air. In April 1985, 1,300 cubic yards of soil were processed after the presence of solvents in the groundwater was identified. The soil material was processed onsite to remove the chemicals of concern and then replaced.

The nearest surface water and point of groundwater release is the Alston Branch of the Leipsic River, approximately 0.4 mile from the site. No wetlands are adjacent to the site. The excavation, processing, and replacement of the soil resulted in an onsite depressed area that holds rainwater for extended periods. As a result, certain wetland type plants with an affinity for wet conditions grow in the vicinity of the depression.

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5.1.3 Scope of Risk Assessment

The risk assessment is a formal procedure with protocols established by the EPA (EPA 1989a, 1989b, 1986a-f, 1985). First, the risk assessment evaluates the chemicals found in the soil and groundwater at the site and determines which site-related chemicals are a potential concern to human health and the environment. Next, it considers the likelihood that humans or the environment are currently exposed to these chemicals or will be at some time in the future. In the final step, it uses the concentrations of the chemicals at the point of exposure to estimate the potential for adverse effects on human health or the environment.

All chemicals, even beneficial ones, may produce some harmful health effects if concentrations are sufficiently high. The factor differentiating safe from harmful is the amount of chemical entering into the body (dose). The risk assessment procedures estimate whether the concentration of a particular chemical is high enough to cause concern for human health and the environment.

Risk assessment protocols are designed to be conservative to account for uncertainties such as the extent of contamination and the presence of highly sensitive individuals in the exposed population. The conservative approach is used to ensure that the results of the risk assessment will protect human health and the environment.

The risk assessment evaluates a reasonable "worst-case" scenario so that regulators and the general public can compare this site with other measures of risk. This approach makes risk assessment a useful tool in ensuring that all aspects of potential adverse health effects have been addressed.

Therefore, the risk assessment is structured to predict the "worst-case" effects that can happen, rather than the most likely or probable potential or actual health impacts.

5.1.4 Organization of Risk Assessment

The risk assessment process consists of four steps: identification of chemicals of concern, exposure assessment, toxicological assessment, and risk characterization. The steps are briefly described below.

- Identification of Chemicals of Concern presents the data and describes the extent of contamination. The chemicals of concern are selected based on validity of the data, frequency of detection, range of concentrations, and comparison with background.

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- Exposure Assessment determines the various ways humans are exposed to chemicals from the site (exposure pathways) and the concentrations actually taken into the body (dose). Exposure pathways are identified according to human populations, flora, and fauna in the vicinity of the site and within the pathways of chemical migration.
- Toxicological Assessment presents the toxicity values derived by EPA toxicologists for known health effects of each chemical. The toxicity values are calculated from studies that relate the level of a chemical taken into the body (dose) to an effect on human health (response).
- Risk Characterization estimates a numerical value for the risk by combining the dose from exposure with the toxicity value. It presents potential carcinogenic and noncarcinogenic health effects. It also presents uncertainty factors or an evaluation of how well these assumptions can be relied upon to give an accurate description of the risks.

5.2 IDENTIFICATION OF CHEMICALS OF POTENTIAL CONCERN

The analytical data for the site have been compiled and evaluated. Those site-related chemicals frequently detected at concentrations above background (chemicals of concern) have been selected for characterization of the risk.

5.2.1 Data Collection Considerations

5.2.1.1 Historical Data

Site analytical data are discussed in detail in Sections 4.2.1 and 4.3.1 of this report. In summary, volatile organic chemicals were detected in 16 shallow and 1 intermediate onsite wells, in 9 shallow offsite wells, and in a limited number of residential wells. Data are available from 1984 to 1990. Evidence suggests that the sources for chemicals detected in these samples are not from activities on the Chem-Solv site, but elsewhere. Post-remediation soil analytical data show that the concentration of volatile chemicals has been reduced below levels of concern.

5.2.1.2 Rationale for Collection of Remedial Investigation Data

For the Remedial Investigation, 14 monitoring well locations were selected to further characterize and delineate the offsite migration of chemicals in the groundwater. Beneath the site is a clay layer that separates a shallow aquifer and a deeper (intermediate zone) aquifer.

Offsite, the silt layer is intermittent and the aquifers are likely to be connected. The 14 monitoring wells, both existing and new wells, were selected to characterize both the shallow zone and the intermediate zone of the aquifer.

Samples were collected from unsaturated soils in locations surrounding the area remediated in 1985 to determine whether the remediation was sufficient horizontally and vertically.

EPA risk assessment protocol recommends that samples from areas not affected by the site be collected to provide background information of naturally occurring chemicals. Chemicals found at concentrations similar to background levels are eliminated from further consideration in the risk assessment. No background soil samples were collected as part of the remedial investigation. However, literature values were used to calculate background soil conditions.

Groundwater

Groundwater samples were collected from 14 monitoring wells. Two of these wells (22A and MWI-1-43) represent upgradient, background samples. These samples were analyzed for Target Compound List (TCL) organics and Target Analyte List (TAL) inorganics. The analytical results for groundwater are presented in Tables 4-6 through 4-11. Filtered and unfiltered samples were analyzed from all wells. Of the 16 groundwater samples (including duplicate samples), six were collected from intermediate-zone wells, one of which is upgradient of the site. The remaining 10 samples were collected from the shallow aquifer, including one background (or upgradient) sample.

Soil

Twenty-one soil samples were collected from seven onsite borings at depths from the upper 6 inches to 20 feet. Eleven samples were collected from the surface soil, defined in this risk assessment as the upper 6 inches to 4 feet. The remaining samples were collected at intervals to 20 feet. These samples were analyzed for TCL organics and TAL inorganics. The analytical results are presented in Tables 4-2 and 4-3.

Background soil samples were not collected, because of difficulties in selecting a representative background area. There are multiple sources of offsite contamination because of the proximity of the highway and agricultural fields. Also, airborne contaminants may have been associated with the explosion and fire. Because the area potentially exposed to any airborne contaminants is unknown, the selection of a representative background sample was not possible.

Literature values reported for soil from the State of Delaware, surrounding states, and the eastern coastal area were used to define background concentrations.

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5.2.2 Data Evaluation Considerations

The existing and RI analytical data on inorganic and organic chemicals in soil and groundwater were compiled and evaluated. The assessment included QA/QC information, location of samples, range of concentrations, and comparison with background.

5.2.2.1 Historical Data

Data collected from previous site investigations and the ongoing residential well-sampling program are presented in Sections 4.3.1 and 4.3.2 of this report. The data were not included in the risk assessment because there are insufficient quality assurance/quality control (QA/QC) samples and documentation. Also, the current RI data is more representative of existing conditions.

The decision to omit historical data does not indicate that the data are inaccurate, but only that there is insufficient information to support a review in accordance with EPA risk assessment protocols. The QA/QC information is used to determine the validity of the data. As discussed in more detail in this section, there is an inherent uncertainty in all analytical results that must be evaluated to determine whether the reported concentration is accurate. The information necessary to perform a QA/QC review in accordance with EPA protocols was not available for the historical data.

The data collected during the RI is considered more representative of existing conditions. The soil and well locations sampled were designed to delineate the extent of contamination, and the samples were collected in accordance with EPA protocols. The most recent historical data were collected in September 1988.

5.2.2.2 Quality Assurance/Quality Control Evaluation of Data

The validity of analytical data is evaluated using QA/QC protocols. QA/QC protocols are used to determine the level of confidence that the chemical concentration reported by the laboratory is the same as the concentration actually present in the sample. QA/QC protocols verify a series of requirements to support the validity of the data, such as proper operation of the analytical equipment, consistent standard methods, correctness of calculations, and any uncertainty associated with the concentrations reported by the laboratory.

Before the selection of chemicals of concern, the data were validated to identify cases where the reported concentrations may be inaccurate (estimated concentrations) or the chemical may not have been present in the sample when it was collected (questionable data).

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Data validation identifies chemical concentrations that could not be measured accurately. These data, called "estimated" or "trace" concentrations, occur when the concentration of a chemical is below a level (quantitation limit) that can be measured accurately, but above a level that can be detected (detection limit). In cases when the result is estimated, the chemical was present in the sample; however, it is not certain whether the actual concentration was greater or less than the reported concentration.

During the collection and handling of samples and during laboratory procedures, chemical compounds can be inadvertently introduced. To account for these accidental additions of chemical contaminants, blank samples prepared in the field or laboratory are also analyzed. Chemicals detected in either the field or the laboratory blank may not actually be present in the sample and may therefore be considered questionable.

Questionable data are defined as sample concentrations within a factor of 10 of the blank concentration for the common laboratory contaminants: methylene chloride, toluene, acetone, phthalate esters, and methanol. For any other compounds detected in a related blank, a factor of 5 is used to define questionable data.

5.2.2.3 Potential Offsite Sources

During the groundwater investigation, several organic chemicals (benzene, toluene, xylene, and benzene-substituted alkanes) were detected in groundwater at Wells 26A and MMS-7-25. As discussed in Section 4.3.2, these compounds are more representative of a fuel source than of site-related chlorinated solvents such as TCE. Information obtained from the DNREC Underground Storage Tank Division has shown that soil at the gasoline station northwest of the intersection of Route 13 and Route 42 contains benzene at 2.1 mg/kg, ethylbenzene at 10 mg/kg, toluene at 16 mg/kg, xylene at greater than 300 mg/kg, and total petroleum hydrocarbons of 410 mg/kg. As discussed in the October 24, 1990, meeting, these data indicate that the source of the organic compounds present in groundwater at MMS-7-25 is not the Chem-Solv site. Therefore, organic chemicals from MMS-7-25 were not included in the risk assessment.

5.2.3 Selection of Chemicals of Concern

5.2.3.1 Chemicals in Soil

No organic or inorganic chemicals of concern were selected in soil because the concentrations detected were in the range of background concentrations, represented isolated events unrelated to previous site activities, or were infrequently detected at low concentrations. The analytical data presented in Table 4-2 are summarized in Table 5-1. A preliminary review of the data was presented to EPA Region III in an

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Interim Document dated June 1, 1990. EPA Region III concurred with the conclusion that there were no chemicals of concern in site soils (Appendix A-10). The following sections provide a summary of the soil sampling results presented in the Interim Document.

For soil exposure, the upper 4 feet of soil was considered the depth of most likely human and environmental exposure. Chemicals found at greater depths were considered qualitatively to describe the extent of any contamination.

Volatile/Semivolatile Organic Compounds

Volatile and semivolatile organic chemicals were detected in a limited number of samples at low concentrations, and most of the data is questionable because of the presence of that chemical in a related blank.

In the 11 shallow soil samples, trichloroethene was detected twice, with a maximum estimated concentration of 6 micrograms per kilogram (ug/kg). Methylene chloride was detected 5 times, but the data are questionable because methylene chloride was also detected in the associated QA/QC samples, except for one sample with a detected value of 4 ug/kg. Acetone was detected 7 times, but all the values are questionable because of blank contamination.

Of the remaining soil samples from depths greater than 2 feet, chloroform was detected in four samples, with a maximum concentration of 8 ug/kg. However, since chloroform was detected only in samples collected from the deeper soils (6 to 20 feet), human or environmental exposure to chloroform is considered unlikely.

Methylene chloride was detected in seven samples; all of these are questionable because of blank contamination.

Acetone was detected in nine soil samples taken from depths greater than 2 feet. Eight of these results were questioned because of blank contamination.

Six soil samples from the 15 collected had detectable levels of semivolatile organic chemicals. Bis(2-ethylhexyl)phthalate, a common laboratory contaminant, was detected in five samples, with a maximum concentration of 510 ug/kg. Only one of these samples was obtained from surface soils; the remaining were collected from depths of 2 to 5.5 feet. Isophrone was detected twice in one boring, with a maximum concentration of 3,100 ug/kg. Benzoic acid was detected in only one sample, at 290 ug/kg.

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Pesticides

The pesticides detected in onsite samples are attributable to farming activities in the adjacent fields. The use of DDT in the United States was banned in 1972, 10 years before operations began at the site in 1982.

The pesticide DDT and its breakdown products, DDE and DDD, were found in 9 of the 15 samples collected throughout the site, at a maximum total concentration of 390 ug/kg (determined by averaging duplicate sample results for soil sample CSB-11 and summing the DDT, DDE, and DDD results).

DDT is not considered site-related. The site is surrounded by agricultural fields, and DDT and its breakdown products are very persistent in the environment; therefore, the presence of DDT in the soils is not unexpected. Literature values report DDT concentrations as high as 1,000 ug/kg in agricultural fields as late as 1983, 9 years after DDT use was banned (ATSDR, 1989a).

Inorganic Compounds

Inspection of Table 5-1 shows that the concentrations of metals found in site soils are well within the background range for this area, with the possible exceptions of lead and cadmium. The maximum onsite lead concentration is 80 mg/kg, compared with the highest value for the area -- 20 mg/kg. The average onsite lead concentration for all samples is 22 mg/kg and, therefore, typical of background. The presence of slightly elevated levels of lead in isolated locations on the site is not unexpected. The impact of the highway and emissions from cars, trucks, and the nearby truck stop (not located onsite) is highly probable.

Cadmium levels are slightly above typical concentrations in Delaware soils. A common source is phosphate fertilizers, which contain 3 to 100 mg/kg of cadmium (ATSDR, 1989[b]). It is likely that fertilizers were used on the fields adjacent to the site.

In addition, metals and metallic compounds were not used as part of the reprocessing activities that took place at Chem-Solv. Therefore, according to the soil data and background information, soils outside the former excavation have not been affected by site activities.

5.2.3.2 Chemicals in Groundwater

The compilation of data for organic compounds in groundwater was based on three sampling events for Wells 5B, 9B, 26A, 33A, 39A, 41A, MMS-5-18, and MMS-6-25. Data from one sampling event were included for the American Roofing and Gearhart/Shane domestic wells (Tables 4-6 and 4-7). Summaries of the data are presented in Tables 5-2 and 5-3.

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Data from four wells were not included (MWI-2-40, MWI-4-40, MWS-3-18, and MWS-7-25). There is no evidence of site-related contamination in these wells. There is evidence that the organic chemicals present in MWS-7-25 are from an offsite source (See Section 5.2.2.3). However, manganese and zinc data for Well MWS-7-25 were included in the risk assessment.

EPA and its representatives concur with the selection of wells (October 24, 1991, meeting minutes; EPA comments for the draft RI Report, dated September 17, 1990, page 19). EPA also recommended that Wells MWS-5-18 and MWS-6-25 not be included in the risk assessment. This recommendation conflicts with a subsequent comment requesting that manganese be included as a chemical of concern. Manganese levels in these wells are elevated above background concentrations. Therefore, data from MWS-5-18 and MWS-6-25 have been included in the risk assessment.

Volatile Organic Compounds

To present a conservative estimate of the risk, all the TCL volatile organic chemicals detected in downgradient wells were included as chemicals of concern, even those chemicals detected infrequently. Eleven volatile organic chemicals are included on this list (acetone; benzene; chloroform; 1,1-dichloroethane [1,1-DCA]; 1,2-dichloroethane [1,2-DCA]; cis-1,2-dichloroethene [cis-1,2-DCE]; tetrachloroethene [PCE]; toluene; 1,1,1-trichloroethane [1,1,1-TCA]; trichloroethene [TCE], and xylene). Six of the chemicals (acetone; chloroform; 1,1-DCA; cis-1,2-DCE; toluene; and xylene) were detected in only 1 of the 10 downgradient well samples. These compounds have all been detected in onsite wells in past sampling rounds; therefore, they were included. The background wells, both shallow and deep, contained no volatile organic compounds.

Semivolatile Organic Compounds

No semivolatiles were positively identified in the April 1990 groundwater samples. Phenol was found in one downgradient, offsite shallow well (MWS-7-25) at an estimated concentration of 9.0 micrograms per liter (ug/l). Phenol, a noncarcinogen, was not included in the chemicals of concern, because it was detected in only one sample at a location that has been affected by offsite sources (see Section 5.2.2.3).

Inorganic Compounds

Two inorganic chemicals found at concentrations above background, manganese and zinc, were selected as chemicals of concern in groundwater. Manganese was found at concentrations above the filtered and unfiltered background concentrations of 81.8 and 117 ug/l, respectively, in all shallow wells except MWS-3-17. No manganese levels in the deeper wells were above background except for the unfiltered sample from MWI-4-40 (96 ug/l).

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Although manganese is a chemical of concern in groundwater, elevated concentrations in soil are not necessarily the source. A plausible explanation can be found in the chemistry of manganese under reducing conditions. Generally, low pH and low dissolved oxygen concentrations are indicative of reducing conditions. Dissolved oxygen in Well 26A is very low (0.7 and 0.8 mg/l). Manganese levels in groundwater at this location are more than 10 times as high as in any other location. In the absence of oxygen, a chemical reaction causes the reduction of manganese to a highly soluble form. Naturally occurring manganese in soil becomes soluble and is mobilized (Metzel, 1983). The cause of the localized reducing conditions in groundwater at this location is unknown. However, the presence of fuel-related organic compounds has been shown to decrease dissolved oxygen in groundwater. Benzene and other fuel-related compounds are present at Well 26A.

Zinc was found at concentrations of 3,810 and 3,910 ug/l in Well 33A. These levels are significantly higher than the maximum background concentration of 296 ug/l. The maximum level detected in any other well is 139 ug/l (Well 26A). There is no clear pattern in the distribution of zinc, suggesting that migration away from Well 33A may be limited. Zinc was not detected in Well 41A, which is located directly downgradient from the site.

Mercury was found at concentrations above background in two wells but was not selected as a chemical of concern. The first well, 9B, is a well that monitors the intermediate zone beneath the site. Mercury was not found in any shallow well except MH-7-25, one of the farthest downgradient wells. Mercury is highly immobile in groundwater (EPA, 1979). There is no evidence to suggest that mercury was handled at the site as shown by the fact that mercury was not detected in the site soils or in the shallow groundwater zone.

Since known site activities involved the use of organic chemicals, there is no evidence that any elevated levels of inorganics are site-related. An alternative explanation is that excavation and mixing of the soil during remediation resulted in increased exposure of the soil to infiltrating rainwater and a temporary increase in dissolved salts or a decrease in dissolved oxygen in the groundwater.

Elevated levels of iron, manganese, sodium, and calcium at the concentrations found do not represent the same level of concern for public health as do other inorganic compounds. They were not considered chemicals of concern.

The majority of inorganic parameters detected above background levels (aluminum, arsenic, calcium, potassium, and sodium) were found in MWI-4-40. This well is located on the Durham property. Mr. Durham has reported difficulties with a high mineral content in his drinking water well. It is likely that the deep aquifer in this area has an area of high dissolved salts.

Tentatively Identified Compounds

Tentatively identified compounds (TICs) were found in samples from Wells 26A and MMS-7-25. The list of chemicals is generally the same for both wells, although the concentrations are higher in 26A. The TICs found in Wells 26A and MMS-7-25, generally components of fuel oils, were not found in any other well on or offsite. This supports the conclusion (see Section 4.3.2) that there may be another source of this material, such as past leakage from offsite underground storage tanks. These chemicals were not included as chemicals of concern, because of the limited number of detections and indications that their presence is not site-related.

Hazardous Substance List Compounds

Split samples obtained by EPA in February 1991 were analyzed for Hazardous Substance List (HSL) compounds. There are differences between the HSL and the TCL parameter list. Trace levels (41.6 ug/l) of five nonchlorinated substituted benzenes were found in Well 26A. These data are consistent with the identification of 29 ug/l of substituted benzenes in Well 26A during the April 1990 sample collection. These compounds are typically associated with a fuel source and not the chlorinated solvents associated with the site.

5.2.4 Summary of Chemicals of Potential Concern

The chemicals of concern for this groundwater include all volatile organic compounds detected during the Remedial Investigation and two inorganic compounds (manganese and zinc). The selection of volatile organics is supported by the analytical data collected during previous investigations and the history of product use at the site.

The TICs were not included as chemicals of concern, because of the limited number of detections and evidence that their presence was not due to site-related activities. HSL parameters were not included, because of the limited number of analyses.

No chemicals of concern were identified in soil samples. The majority of the volatile detections are questionable; the semivolatiles were found in isolated samples; and the inorganic parameters are within literature values for background.

5.3 EXPOSURE ASSESSMENT

Exposure assessment determines the pathways that may result in human exposure, the mass of chemicals at the point of exposure, and the concentration of each chemical absorbed by an exposed individual on a daily basis (chronic daily intake, CDI).

5.3.1 Characterization of Exposure Pathways

The only complete exposure pathway identified is residential use of the groundwater. Currently, two drinking-water wells are within the area defined by the near or far monitoring wells. Other residential wells are adjacent to the plume. DNREC has a quarterly monitoring program for potentially affected wells, most of which are at greater depths than the area of contamination.

5.3.2 Identification of Exposure Pathways and Assumptions

Exposure pathways include all the various ways in which humans come in contact with the chemicals of concern, either currently or at some time in the future. Exposure pathways are evaluated by considering direct contact with the media of concern (e.g., drinking water) and the potential for chemicals to migrate from one medium to another (e.g., volatilization of chemicals from groundwater into the air).

At this site, the medium of concern is groundwater, and the chemicals of concern are several volatile organic chemicals. The exposure pathway identified is:

Residential Use of Groundwater

- Ingestion of groundwater
- Inhalation of indoor air
- Dermal absorption during showering and bathing

The potential for contamination of vegetables and fruits during watering and the release of contaminants to surface water was also considered. Potential exposure via the ingestion of home-grown fruits and vegetables that were watered with groundwater is considered negligible because the chemicals of concern are volatile organic chemicals. Since these chemicals will volatilize during the watering process, they have little or no potential for accumulation in home-grown foods.

The distance to the nearest point of surface water discharge is 0.4 mile, and low concentrations of volatile chemicals of concern indicate that the potential for elevated concentrations in this creek is highly unlikely. Nevertheless, an exposure pathway quantified for this risk assessment (dermal absorption during showering and bathing) can be used to semiquantitatively evaluate exposure in the stream.

Exposure during recreational use of the stream will be primarily dermal, with occasional wetting of the hands, feet, and lower legs of children. The use of the exposure pathway for dermal absorption during showering and bathing assumes daily contact with groundwater over the entire body. If this pathway poses no significant risk, sporadic dermal exposure to water in the stream will pose even less risk. The dilution factor is estimated in the Environmental Assessment (Section 5.6).

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The objective of the exposure assumptions is to determine how much of the chemical is actually taken into the body (dose). The dose received daily is expressed as the milligrams of contaminant per kilogram of body weight per day (mg/kg/day).

In risk assessment, it is seldom possible to measure specific dose for each identified exposure pathway. As a result, it is necessary to use an estimation of dose based on a series of assumptions, such as how much water the average person drinks. These assumptions were developed from EPA Region III guidance and the most current Superfund Risk Assessment guidance documents (EPA, 1989a, 1989b, and 1989c). The assumptions used in calculating the exposure for each pathway are presented in Table 5-4. The methods and calculations for dose are presented in Appendix P.

The averaging time is the time period over which exposure is assessed. Carcinogenic risk is calculated for adults only using a 30-year exposure period with an averaging time of 70 years. For chemicals with noncarcinogenic effects, the exposure period and averaging time is 5 years for children and 30 years for adults.

5.3.2.1 Ingestion of Drinking Water

The standard assumptions used for drinking-water assessments are ingestion of 2 liters (a little over 2 quarts) of water a day by a 70-kilogram (154-pound) adult and 1.3 liters a day for a 17-kilogram child (EPA, 1989a and 1989b). This assumption includes water that is consumed as coffee, juices, and other beverages containing tap water (EPA, 1989b). In reality, people in the United States consume less than 2 liters a day of tap water. Sixty percent of the population consume less than 1.5 liters a day (EPA, 1989c).

5.3.2.2 Inhalation of Indoor Air

At this time, there is increasing awareness that inhalation of volatile chemicals that accumulate in indoor air can play a significant role in exposure. Chemicals enter the indoor air during everyday household use such as washing clothes, showering, bathing, and flushing the toilet. However, there is still considerable controversy over the methods that can be used to estimate the dose from this exposure (EPA, 1989a and 1989b).

For inhalation, a draft whole-house model from the Office of Drinking Water was used (Appendix Q). Briefly, the model assumes that a certain fraction of the chemical in the water entering the house volatilizes and accumulates in the indoor air in proportion to the air exchange or ventilation rate of the house. The exposed individual is assumed to remain indoors 24 hours a day.

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The model has are two chemical-specific parameters: (1) the fraction of chemical retained in the lungs and (2) the fraction of chemical that volatilizes out of the water. The fraction retained by the lungs was assumed to be 100 percent for all chemicals. For the fraction volatilizing, a factor of 50 percent was used. This value is representative of volatile chemicals (Appendix Q).

A convenient way to express exposure via inhalation is drinking water equivalents (DWE). The use of DWE allows direct extrapolation from exposure via ingestion of water to exposure via inhalation for the same concentration of a chemical in the water. Exposure for adults and children via inhalation is 0.95 times the DWE for the chemicals regarded as volatile.

5.3.2.3 Dermal Exposure

Chemicals can enter the body via adsorption through the skin during showering and bathing. The dose received through dermal contact with water is calculated from assumptions on the length of time the person is in the shower or bath (exposure time), the amount of skin in contact with the water (skin surface area), the rate at which the chemicals penetrate the skin (dermal permeability), and the frequency of daily bathing or showering activities per year.

The amount of skin in contact with water was estimated as 1.94 square meters for adults. This value is suggested in the current EPA protocol and is considered to represent the 50th-percentile total body surface area for adult males (EPA, 1989b). A value of 0.7128 square meters was used as the amount of skin in contact with water for children (EPA, 1989b).

There is very little information of dermal adsorption rates for individual chemicals (EPA, 1989a). For this risk assessment, the values were derived from data provided by EPA Region I. They are presented in Appendix R.

5.3.3 Groundwater Exposure Concentrations

The data for the groundwater monitoring wells were evaluated to determine which wells were representative of the plume. The data from these wells were then combined to estimate water concentrations in a hypothetical drinking-water well placed within the plume.

5.3.3.1 Data Evaluation

Shallow and Intermediate Aquifer Data

The data for groundwater from intermediate- and shallow-zone wells were combined to simulate groundwater use in this area. Area drinking-water wells are generally installed at depths greater than 100 feet. However,

the high porosity of the soil and the absence of a confining aquifer in all areas suggests that water from shallow aquifers is likely to be included in the recharge for the intermediate wells. In this way, human exposure to water from the shallow aquifer may occur.

Plume Definition

The downgradient wells were divided into two groups based on presence of chemicals, direction of groundwater flow, and probable location of the plume. The first group, the near wells, represent the five wells closest to the site and most likely to represent the plume. The data for the near wells, 5B, 9B, 26A, 33A, and 39A, are presented in Table 5-2.

The second group, the far wells, included all the near wells plus three additional monitoring wells (41A, MWS-5-18, and MWS-6-25) and two domestic wells (American Roofing and Gearhart/Shane) (Table 5-3).

5.3.3.2 Exposure Concentration

The data from within the two well groups were combined to estimate a probable concentration of each chemical of concern for a hypothetical well drawing water from the center of each plume. The data were combined into an arithmetic average from which a Reasonable Maximum Exposure (RME) concentration was calculated (Table 5-5). Methods used in handling of chemical data are in accordance with guidance received from EPA Region III (Appendix S) and Risk Assessment Guidance for Superfund (EPA, 1989).

Average Concentration

The arithmetic average was obtained using data from the near and far well groups. Data from duplicate and split samples were averaged into a single data point before calculating the group average.

The use of the arithmetic average requires statistical support and justification. The most quantitative form of statistical analysis, parametric statistics, requires that the arithmetic average be calculated directly only when the data are normally distributed. Normal distribution represents one of many patterns for data. A more typical pattern for environmental data is a log normal distribution. There are methods for adjusting log normal data to make it fit a normal distribution before calculating the average.

Statistical evaluation of the data for the Chem-Solv site indicated that neither a normal nor a log normal distribution described the pattern of the data, nor did one fit better than the other.

Other techniques for adjusting data to a normal distribution were not evaluated. The arithmetic average was selected because this value represents an unbiased estimate of the mean (Gilbert, 1987). Since the

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data tend to be skewed to higher concentrations, it is highly likely that the arithmetic-average calculation results in a higher, more conservative estimate of the concentration than any average calculated with adjusted data.

Incorporation of Nondetected and Questionable Data

Two key issues in the calculation of the average are (1) the method used to incorporate questionable or nondetected data and (2) the method used to calculate the upper bound 95 percent confidence interval for the arithmetic average concentrations.

When a chemical is not found in a sample, the laboratory reports the value as nondetected above a certain level. This means that if the chemical is present, the concentration is below the detection limit reported. However, it is also possible that the chemical was not present in the sample.

There are several approaches for the use of data reported as nondetected. The data can be excluded from the data base, listed as zero, or listed as one half the detection limit. For this risk assessment, arithmetic means were calculated using one half the detection limit for data reported as less than the detection limit. Method detection limits were obtained from the contract laboratory (IEA) and from EPA and are listed in Appendix W. Detection limits have not been established by the DNREC laboratory; therefore, one half the quantitation limit was used to calculate average concentrations.

When a compound was detected (quantified or estimated) but the value is questionable because the chemical was also found in a related blank sample, one half the reported sample value was used.

Calculation of Reasonable Maximum Exposure (RME)

Before 1989, EPA protocol required that the risk associated with the maximum concentration be evaluated. However, current protocol recognizes that the maximum concentration does not represent a reasonable exposure concentration. At this time, EPA recommends that the 95 percent upper-bound confidence interval for the arithmetic mean be used to represent a reasonable maximum exposure (RME).

In simpler terms, the average or mean represents the central observation or most commonly observed concentration if a very large number of samples (e.g., greater than 100,000) were collected. If the data behave according to certain assumptions, in 50 percent of the samples the actual concentration is predicted to be lower than the average, and in 50 percent of the samples the concentration is predicted to be higher than the average.

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The RME is used to account for the fact that the actual number of samples is relatively small to accurately predict the average. The RME is a statistical estimate of the highest average concentration predicted to occur in 95 out of 100 sets of samples.

The RME is a conservative estimate of the risk since it assumes that a concentration equal to the upper-bound confidence interval of the average for every chemical of concern is present in one hypothetical residential well.

The methods and equations used to calculate the RME are presented in detail in Appendix T. The methods are those recommended by EPA risk assessment protocol and presented in Gilbert, 1987.

5.3.4 Identification of Uncertainties

Exposure assessment assumptions are selected to estimate an upper concentration limit and the amount of each chemical that individuals take into their bodies.

Exposure assumptions tend to estimate the risk for a large percentage of the population and, therefore, to be protective of human health. Each of the assumptions and its basis were discussed in Section 5.3.2. The assumptions tend to be conservative. For example, the carcinogenic risk assumes that exposure occurs daily for 30 years.

The estimated exposure concentrations tend to be conservative for two reasons. First, the average assumes that all the chemicals are present at one half the detection limit for samples with nondetected results. It is likely that for many of the wells, the chemicals are not present at all. Also, the RME represents a concentration in the upper-bound confidence interval. The rationale behind the use of the RME is that an area of higher concentrations may not have been detected. The sufficiency of the number of wells and the appropriateness of their locations improve the confidence level in the data base.

There is some uncertainty in the exposure assessment associated with the lack of chemical-specific dermal-permeation constants for several potential chemicals of concern (Appendix Q). Constants selected for these compounds were based on similarities in chemical composition because literature values for many compounds are not available. The absence of chemical-specific permeation constants may have either overstated or understated the risk.

5.3.5 Summary of Exposure Assessment

The only medium of concern identified was the groundwater. The exposure pathway identified was the residential use of groundwater. This pathway includes the ingestion of water, inhalation of airborne contaminants, and dermal absorption of contamination through water use. Future use of the site is considered to be the same as the present use.

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5.4 TOXICITY ASSESSMENT

The toxicity profiles in Appendix U summarize chemical and toxicological information on the chemicals of concern. A more technical presentation of toxicological data for the chemicals is given in Appendix V. Unless otherwise noted, the technical toxicological profiles were obtained from the Integrated Risk Information System (IRIS).

EPA toxicologists derived toxicity values after an extensive review of the available data for each chemical. Although data from epidemiological studies on human exposure are the most valuable, generally the only data available are laboratory studies with animals. There is some uncertainty in results from using laboratory studies with animals because the animals are usually exposed to high doses of chemicals for short periods of time. Dose-response evaluations use this data to assess the potential for health effects in humans exposed to low doses for long periods.

Toxicity values for each parameter can differ depending on the way humans are exposed to the chemical. Chemicals can be taken into the body through the gastrointestinal tract after ingestion of soil, sediment, or water (oral); into the lungs after inhalation of vapors or particulates in the air (inhalation); and into the body through the skin after contact with chemicals in soil, sediment, or water (dermal).

Some chemicals are not as potent via one exposure route as via another. Thus, different health effect factors have been established for each route of exposure. For example, certain metals, such as hexavalent chromium, have been shown to have carcinogenic effects via inhalation but not via ingestion.

Chemicals can also have both carcinogenic and noncarcinogenic effects. Therefore, it is possible that a chemical can have both a carcinogenic health factor for oral and inhalation exposure and a noncarcinogenic health factor for oral and inhalation exposure.

The toxicity values used for this risk assessment to assess human health effects are presented in Tables 5-6 and 5-7. The following sources were used to identify toxicity values and are listed in order of preferential selection.

Integrated Risk Information System (IRIS)

IRIS is an on-line computer data base that presents toxicological assessments of chemicals and the status of EPA-approved toxicity values. The toxicity values obtained through IRIS are current as of May 1991.

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Health Effects Assessment Summary Tables (HEAST)

The EPA Office of Emergency and Remedial Response publishes a quarterly summary of toxicity values from a variety of recognized sources in addition to IRIS. The toxicity values obtained through HEAST were taken from the fourth quarter of 1990.

5.4.1 Toxicity Information for Noncarcinogenic Effects

The potential for adverse noncarcinogenic health effects is estimated with a toxicity value known as a reference dose (RfD). RfDs are associated with adverse health effects, which are also referred to as toxicity end points. The RfDs and toxicity end points for the chemicals of concern are listed in Table 5-7.

Reference Dose

The model to determine RfDs from the dose-response assessment assumes that there is a concentration for noncarcinogens below which there is little potential for adverse health effects over a lifetime of exposure. The RfD is designed to represent this threshold level.

The RfD is calculated from the highest chronic (long-term) exposure level that did not cause adverse effects (the no-observed-adverse-effect level, or NOAEL) in animals. The NOAEL is divided by a factor to account for any uncertainty such as using data on animals to predict effects on humans and an allowance for sensitive individuals. Uncertainty factors range from 1 to 10,000, based on the confidence level associated with the data. The resulting RfD (mg/kg of body weight per day) is used to quantify the risk.

Toxicity Endpoint

The determination of adverse impact for noncarcinogens is based on a wide variety of responses, ranging from increases in organ weight and changes in blood chemistry to death. Noncarcinogenic effects are also defined by the toxicity endpoint in laboratory animals used to identify the RfD.

5.4.2 Toxicity Information for Carcinogenic Effects

The EPA approach for evaluations of carcinogens assumes that exposure to any level of a carcinogen, no matter how low, has some probability of causing cancer. The toxicity value calculated for carcinogens is known as the potency factor (PF). The weight-of-evidence is a qualitative descriptor important to the interpretation of carcinogenic risk. The PFs and weight-of-evidence for the chemicals of concern are listed in Table 5-6.

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Potency Factors

The PF is calculated with a mathematical model that draws a line based on data from laboratory animals exposed to high doses and extends it to predict potential increases in cancer rates for humans exposed to low doses. Then confidence intervals are calculated for the line. The slope of the line that represents the 95 percent confidence interval is known as the potency factor or slope factor. The use of the upper-bound confidence interval means that there is a 95 percent probability that the actual risk will be less than that predicted by the model. The unit for the PF is (mg/kg of body weight per day)⁻¹.

Weight-of-Evidence

The weight-of-evidence reflects the degree of confidence in the data used to determine that the chemical is a human carcinogen. EPA toxicologists recognize that the risks associated with a known human carcinogen, based on epidemiological studies, should be evaluated differently from those of a chemical that causes tumor production in a limited number of laboratory animals. Each carcinogen is assigned to a group according to the quality and the quantity of evidence for carcinogenicity in humans and animals. The definitions for the groups are presented in Table 5-8.

5.4.3 Chemicals Without Available EPA Toxicity Values

Uncertainty is low with regard to omission from the risk calculations of chemicals without EPA toxicity values. No toxicity values are currently available for 1,1-dichloroethane and cis-1,2-dichloroethene. However, these compounds were each detected at one location at low levels and may be excluded from the risk assessment. The only other chemicals not included in the risk assessment are the TICs. In the majority of the samples, the TICs are listed as unknown. In the two wells with names assigned to the chemicals, 26A and MSW-7-25, the TICs are generally associated with petroleum hydrocarbons. The adverse health effects associated with long-term exposure to petroleum hydrocarbons have been attributed only to the carcinogenic components such as benzene and some carcinogenic polyaromatic hydrocarbons (PAHs) (Bingham et al., 1980). Benzene is included in the risk assessment; no PAHs were detected in the groundwater.

5.4.4 Uncertainties Related to Toxicity Information

In the general profiles, much of the information on human health effects from chemicals is based on occupational exposure. Adverse effects observed in the workplace are a valuable source of toxicological information. Some of the health effects studies discussed in the toxicological profiles presented in Appendices U and V may have been used by EPA toxicologists to help determine health effects at much lower concentrations. However, the reader should keep in mind that many of the health effects observed for the workplace are acute, or short-term, high-level effects. Workplace exposure levels are generally much higher than



the potential exposures encountered at the Chem-Solv site. The adverse effects presented in the general profiles (Appendix U) are not necessarily comparable to the potential effects related to exposure concentrations predicted by the Chem-Solv risk assessment.

The dose-response assessment for the majority of chemicals relies on an extrapolation of known effects on animals to humans. The use of data based on animal studies to predict impacts on humans is an area of uncertainty, particularly because different species of animals respond with different sensitivities to chemicals. Also, there are many models available that extrapolate animal data to humans, and the toxicity values generated from the same data by different models can vary substantially. The models used by the EPA tend to be conservative and are unlikely to underestimate the risk. The method used by the EPA for PFs uses a 95 percent upper-bound confidence interval, which means that while the actual risk is unlikely to be higher, it could be much lower.

5.5 RISK CHARACTERIZATION

The risk characterization combines the dose with the toxicity value to estimate a numerical value for the risk. There are several differences between the numerical value used to describe risk for carcinogens (cancer risk) and the value used for noncarcinogens (hazard index, HI). The methods and results for this risk assessment are presented separately for carcinogens and noncarcinogens.

5.5.1 Carcinogenic Risk Characterization

5.5.1.1 Methods

Carcinogenic risk is calculated by multiplying the dose (chronic daily intake [CDI]) times the slope factor. The resulting value is the probability of an increase in the incidence in cancer and should not be directly interpreted in terms of the number of cases of cancer in the exposed population. The risk level of 1×10^{-6} can also be viewed as a one-in-one-million probability that there will be one additional case of cancer.

Carcinogenic risk estimates for the same chemical in different exposure pathways are added together. Also, carcinogenic risks for different chemicals are added together to determine the risk associated with the exposure pathway for all the chemicals.

5.5.1.2 EPA Guidance on Carcinogenic Risk

EPA has not established an acceptable level of risk. A range of carcinogenic risks of 1×10^{-4} to 1×10^{-6} has been identified for Superfund sites (NCP, 1990). This means that target risk levels should be between

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an upper limit of 1 in 10,000 probability of cancer incidence to a lower limit of 1 in 1 million. A total cancer risk of 1×10^{-6} is often used as a benchmark by state and federal regulatory agencies.

5.5.1.3 Discussion and Interpretation of Carcinogenic Risk Results

The results of the carcinogenic risk calculations for each exposure pathway are presented in Appendix P. Tables 5-9 and 5-10 present the carcinogenic risk associated with each chemical and pathway for the near and far wells, respectively.

The average carcinogenic risk associated with the near wells for all pathways was within the EPA target risk range (1×10^{-4}), with a value of 4×10^{-5} . The risk associated with the RME however, was at the lower limit of this range. Trichloroethene accounted for greater than 50 percent of the total cancer risk within the near well group.

For the far wells, the carcinogenic risk associated with the average exposure for all pathways was within the EPA target risk range, with a value of 3×10^{-5} . RME cancer risks (6×10^{-5}) were also within the target range. For the far wells, the highest carcinogenic risk was attributed to TCE (greater than 60 percent), followed by benzene.

Ingestion of Groundwater

The average and the RME carcinogenic risk associated with ingestion of groundwater for the near wells were 2×10^{-5} and 5×10^{-5} , respectively. Approximately 30 to 40 percent of the risk can be attributed to trichloroethene, and 30 to 40 percent to benzene. For the far wells, the carcinogenic risk associated with the average and the RME were 1×10^{-5} and 3×10^{-5} , respectively. Again, benzene and trichloroethene contributed to the majority of the risk. Approximately 25 to 30 percent of the risk can be attributed to benzene, and 33 to 50 percent to trichloroethene. 1,2-Dichloroethane contributed approximately 10 to 20 percent of the carcinogenic risk for the far wells.

Inhalation of Indoor Air

The average and the reasonable maximum carcinogenic risk associated with the inhalation of airborne contaminants that have volatilized from the groundwater for the near wells were 2×10^{-5} and 6×10^{-4} , respectively. The majority of the risk (approximately 70 percent) was attributed to trichloroethene, while benzene represented the remainder. For the far wells, the carcinogenic risk values associated with the average and RME were 1×10^{-5} and 3×10^{-5} , respectively. TCE contributed approximately 70 to 80 percent of the risk, and benzene represented the remainder.

Dermal Absorption of Groundwater During Use

For the near wells, the average and the reasonable maximum carcinogenic risk value associated with dermal absorption of contaminants were 3×10^{-6} and 8×10^{-6} , respectively. The majority of the risk was attributed to potential exposure to benzene and TCE. However, 67 to 88 percent of the total risk was attributed to benzene exposure, while less than 10 percent was due to TCE exposure. The carcinogenic risks associated with the average and RME for the far wells were 2×10^{-6} and 5×10^{-6} , respectively. The majority of the risk (approximately 50 to 60 percent) was attributed to benzene exposure. Trichloroethene contributed less than 5 percent of the cancer risk.

A General Discussion of Cancer Risks

The interpretation of carcinogenic risk is complicated by the absence of guidance from the federal government on acceptable risk. Instead, the decision to remediate a site and the determination of a cleanup level is made on a case-by-case basis within the Superfund target range.

The target carcinogenic risk (1×10^{-4} to 1×10^{-6}) identified for Superfund is consistent with that for other federal agencies that make risk-based decisions. A review of criteria for foods, pesticide use, and occupational safety shows that other agencies, such as the Food and Drug Administration (FDA) and Occupational Safety and Health Organization (OSHA), frequently make risk-based decisions within this range. Sometimes risk-based decisions have used cancer risks as high as 1×10^{-3} (Rodericks, et al., 1987).

It is also helpful to consider the risks associated with this site in a context of normal, everyday risks. The carcinogenic risk associated with natural background radiation is greater than 1×10^{-4} . Strictly speaking, unavoidable risks, such as natural radiation and voluntary risks (such as smoking) cannot be compared to those risks associated with chemical contamination due to human activities. This information on HI value is included just to help the reader's perspective on various levels of cancer risk.

5.5.2 Noncarcinogenic Risk Characterization

5.5.2.1 Methods

The numerical value for the noncarcinogenic HI value is the Hazard Index (HI). The HI is the ratio of the dose to the RFD and is calculated by dividing dose (chronic daily intake or CDI) by the RFD. The HI is not strictly an estimate of the risk, but a number that compares CDI with a level considered to have limited potential for lifetime health effects. Hence, HI values greater than 1 show that exposure exceeded the acceptable daily level, while HI values less than 1 indicate that lifetime exposure has limited potential for causing an adverse effect in sensitive populations.

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Similar to cancer risks, the HI values for each chemical are summed together to assess the overall potential for noncarcinogenic effects. EPA developed this approach based on the assumption that simultaneous subthreshold exposures to numerous chemical compounds can result in adverse health effects (EPA, 1986).

5.5.2.2 EPA Guidance on Hazard Indices

EPA has not established specific guidance for acceptable HI values. However, since an HI value of 1 indicates that lifetime exposure has limited potential for causing an adverse effect in sensitive populations, values less than 1 can generally be considered acceptable. Values greater than 1 are usually given closer attention. For values greater than 1, the magnitude of the uncertainty factor and toxicity endpoint are included in the evaluation.

5.5.2.3 Discussion and Interpretation of Hazard Indices

The results of the HI calculations for each exposure pathway are presented in Appendix P. HI calculations included values for both adults and children. Tables 5-11 and 5-12 present the hazard index associated with each chemical and pathway for the near and far wells.

The HI values for individual chemicals and the total HI exceeded the value of 1 for ingestion of groundwater in both the near and the far wells. The total HI values did not exceed unity the value of 1 for the inhalation or dermal exposure pathways. Therefore, for the dermal and inhalation exposure pathways, potential noncarcinogenic health effects are not expected. The majority of noncarcinogenic risk for ingestion of groundwater was attributed to manganese. Without the HI value associated with manganese, the total HI values fall below a value of 1.

Ingestion of Groundwater

For adults, the average and the reasonable maximum HI values associated with the near wells were 2 and 4; and with the far wells, 3 and 8, respectively. For the near wells, the HI associated with manganese represented 50 to 100 percent of the total HI value. For the far wells, the majority of the noncarcinogenic risk was attributed to manganese and zinc. Manganese represents 88 to 100 percent of the total HI value.

For children, the average and the reasonable maximum HI values were 4 and 1 for the near wells and 2 and 5 for the far wells, respectively. Again, 80 to 100 percent of the risk was attributed to manganese.

Inhalation of Groundwater During Use

The average and the reasonable maximum HI values associated with the inhalation of airborne contaminants from the groundwater for the near wells were 0.008 and 0.02 for adults and 0.02 to 0.04 for children,

respectively. The majority of the HI value (approximately 75 percent) was attributed to acetone and tetrachloroethene. The average and RME HI for the far wells were 0.01 and 0.02 for adults and 0.03 and 0.04 for children, respectively. Acetone, tetrachloroethene, xylene, and chloroform contributed approximately 70 to 80 percent of the total HI value.

Dermal Absorption of Groundwater During Use

For the near wells, the average and the reasonable maximum HI values associated with the dermal absorption of contaminants were 0.003 and 0.004 for adults and 0.004 and 0.006 for children, respectively. The majority of the HI value was almost exclusively the result of tetrachloroethene. The HI values associated with the average and RME for the far wells were 0.004 and 0.005 for adults and 0.005 and 0.007 for children, respectively. The majority of the HI value (approximately 50 to 75 percent) was attributed to tetrachloroethene.

5.5.3 Uncertainties in Risk Characterization

Issues that represent some uncertainty in the HI value assessment include the toxicological effects of chemical mixtures and the presence of unknown chemicals.

Very little information is available on the toxicological effects of mixtures. In some cases, the presence of several chemicals together may result in an enhancement of the overall toxicity (synergistic) effects or a reduction in the toxic effects (antagonism). There is uncertainty associated with having many chemicals together.

Last, the chemical analyses were for specific parameters. The chemicals evaluated are those that have been identified as the most important chemicals in air, soil, and water. The possibility exists that other chemicals that were not detected are present.

The information included in the general toxicity profiles (Appendix U) represents a broad spectrum of studies that are available on health effects. The conclusions may or may not have undergone extensive review to determine their significance or validity. The technical profiles discuss the adequacy of the studies presented and define those which EPA considers adequate to support an assessment of the adverse health effects of the chemical.

5.6 ENVIRONMENTAL ASSESSMENT

The environmental assessment determines the potential for adverse health effects to the environment using essentially the same approach as the HI value assessment used for human health, with the addition of a site biological survey. The steps include a description of relevant aspects

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of the site, identification of chemicals of concern, exposure pathways, toxicity assessment, and HI value characterization. The final step is a survey of the site conducted by a trained field biologist to determine any observable impacts.

5.6.1 Site Description

The aspects of the site description relevant to the environmental assessment are the site's proximity to surface water, points of discharge for groundwater, and terrestrial community. Surface water at the Chem-Solv site infiltrates into the soil or runs onto the adjacent highway, so there are no surface drainage bodies of concern. The point of groundwater discharge is 0.4 mile from the site.

The terrestrial plant and animal community on the site is the environmental receptor of concern. Therefore, soil is the medium of concern because it represents the only completed exposure pathway.

5.6.2 Identification of Chemicals of Concern

There are no chemicals in the soils at significant concentrations above background (see Section 5.2.3.1).

The chemicals of concern in groundwater were evaluated for potential impacts on aquatic life at the point of release into the nearest surface water. The evaluation compared the calculated concentrations at the point of release with a water quality guideline (Table 5-14).

The concentration at the point of release was calculated from a dilution factor for the water shed surrounding the site. A dilution factor of 15 was estimated by dividing the surface area of the site water shed ($5.3 \times 10^6 \text{ ft}^2$) (Figure 4-4) by the area of the far well plume ($3.6 \times 10^5 \text{ ft}^2$). He assumed that there was no loss or attenuation of the chemicals while moving approximately 0.4 mile through the soil to the Alston Branch.

The concentration in the groundwater was compared with a water quality guideline for aquatic toxicity impacts. The water quality guidelines were taken or derived from aquatic toxicity data published by EPA (EPA, 1986). Acute guidelines are protective during short-term exposure at the point of groundwater release, and chronic guidelines are protective for long-term exposure. The chronic guidelines apply to completely mixed instream concentrations. The results of the environmental assessment show that there is negligible or no potential for impact to aquatic life and protective on aquatic life. All RME concentrations are below chronic toxicity guidelines.

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The predicted concentrations are conservative estimates because of two assumptions used in the dilution factor. These assumptions are explained in the following discussion using zinc as an example. The first conservative assumption is that dilution in the stream from water outside the site-specific water shed is not included. Groundwater released into the Alston Branch will be mixed with upstream water. The chronic criteria apply to this mixed instream concentration.

The second conservative assumption is that the dilution factor assumes no loss or attenuation of the chemical during groundwater transport. Zinc is highly immobile and unlikely to migrate a significant distance. Evidence in the scientific literature and site data supports this. Research studies have shown that zinc in groundwater becomes adsorbed onto soil particles and is not transported (EPA, 1986; Brennan and McGrath, 1988). Also, an inspection of site data shows that the concentration of zinc in groundwater decreases by a factor of more than 10 immediately downgradient of the well with the highest concentrations (33A). When the data from this well are excluded, zinc concentrations at the point of release from the site are below background.

5.6.3 Biological Site Assessment

On June 15, 1990, a qualitative analysis of the plant communities was conducted at the site. The purpose was to describe the terrestrial community and make a qualitative determination of plant distribution patterns.

The area of investigation was confined to the area within the chain-link fence. The study area included Well 3A and the remains of a concrete pad in the north-central portion of the area (Figure 5-1). The entire study area is characteristic of an early successional stage meadow. Within this meadow, three microcommunities were defined, based on patterns in the distribution of species. Each of the three communities separately inhabits approximately one third of the site. A presence/absence matrix of the predominant taxa observed on the Chem-Solv site is provided in Table 5-15. Four photographs of the site are presented in Figure 5-2.

Area 1, the western one third of the site, has more perennial taxa than Area 2, and the dominant vegetation is several species of clover, cow vetch, fleabane, plantain, ironweed, and several perennial grasses (Table 5-15, Figure 5-2, Photograph 1). In Area 2, the middle one third of the site which includes Well 3A, the dominant vegetation is similar to Area 1 and likewise includes several species of clover, cow vetch, fleabane, plantain, ironweed, and perennial grasses. Photographs 2 and 3 depict representative portions of this area.

Area 3, the eastern one third of the site, is the area where remediation has occurred. Although this area supports many of the same plant taxa as Areas 1 and 2, several of the more common taxa in the other areas are absent from Area 3. The most conspicuous absences include

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fleabane, plantain and most of the perennial grasses. Area 3 is the only one of the three areas to contain taxa (e.g., rush) with an affinity for wet conditions. Photograph 4 depicts Area 3.

All three communities are characteristic of early successional stages. The high proportion of legumes (e.g., clover and cow vetch) suggests poor nutrient conditions in the soil. In succession, nitrogen fixers (plants that can take atmospheric nitrogen and convert it to a form usable by most other plants) are typically the first plants to colonize a recently disturbed area. As succession proceeds, annual taxa are next to invade, and these annual plants are then typically outcompeted and displaced by perennial taxa.

The most likely explanation for the differences in the plant communities on the site is based on the site's history. The three plant communities appear to have different histories of disturbance. Area 3 is the most recently disturbed. The date of disturbance can be traced to the remediation of the soils. Thus, this area supports the lowest number of perennial taxa compared with Areas 1 and 2. Area 1 supports the greatest number of perennial taxa and is likely to be the oldest of the communities. Area 2 is intermediate in occurrence of perennials and is likely to have been disturbed during the installation of Well 3A. Therefore, the differences in the communities can best be explained by their age. The occurrence of hydrophytes (i.e., moisture tolerant plants) in Area 3 can be explained by topography. Area 3 contains a low lying area where water accumulates after precipitation. Many of the predominant taxa in Areas 1 and 2 cannot tolerate such wet conditions.

5.7 CONCLUSIONS OF THE RISK ASSESSMENT

The following paragraphs summarize the Chem-Solv assessment conclusions (Table 5-13).

- Risk assessment protocols are designed to be conservative to account for uncertainties such as the extent of contamination and the presence of highly sensitive individuals in the exposed population. The conservative approach is used to ensure that the results of the HI value assessment will protect human health and the environment.
- The chemicals of concern at the site include the 11 volatile organic chemicals detected in the groundwater: acetone, benzene, chloroform, 1,1-dichloroethane, 1,2-dichloroethane, cis-1,2-dichloroethene, tetrachloroethene, toluene, 1,1,1-trichloroethane, trichloroethene, and xylene. Manganese and zinc are also included as chemicals of concern.

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- Total carcinogenic risk falls within the target range for Superfund sites of 10^{-4} to 10^{-6} . In the near-well group, those most likely to contain chemicals from site-related activities, the maximum or RME carcinogenic risk is 4×10^{-5} . The carcinogenic risk associated with the average concentration is 1×10^{-4} . The majority of the risk (greater than 50 percent) is due to trichloroethene.
- In the far-well group, the maximum or RME carcinogenic risk is 3×10^{-5} . The carcinogenic risk associated with the average concentration is 6×10^{-5} . The majority of the risk (greater than 60 percent) is due to trichloroethene.
- Total noncarcinogenic risk values are above the target range (HI value of 1 or less). Hazard index values of greater than 1 were calculated for ingestion of groundwater for both the near- and the far-well groups and for both adults and children. However, manganese attributed to almost all of the HI value (60 to 100 percent). Available information suggests that manganese is not site-related. If manganese is excluded from the evaluation of noncarcinogenic risk, hazard indices are less than 1 for both the near and far well group and for both adults and children.
- There is no evidence of widespread distribution of the site-related chemicals, i.e., chlorinated solvents. Trichloroethene was detected in 3 of 12 downgradient wells, and tetrachloroethene was detected in 2 of the 12 wells.
- Evidence suggests that some or all of the contaminants in Wells 26A and MWS-7-25 may be due to leakage of gasoline or other fuel from former offsite underground storage tanks. The chemicals without positive identification, TICs, in these wells are components of combustion fuels. Both carcinogenic and noncarcinogenic risk may be overestimated because analytical data from Well 26A are included in risk assessment calculations to provide a conservative estimate of risk. However, both carcinogenic and noncarcinogenic risk may be overestimated, especially noncarcinogenic risk attributed to manganese.

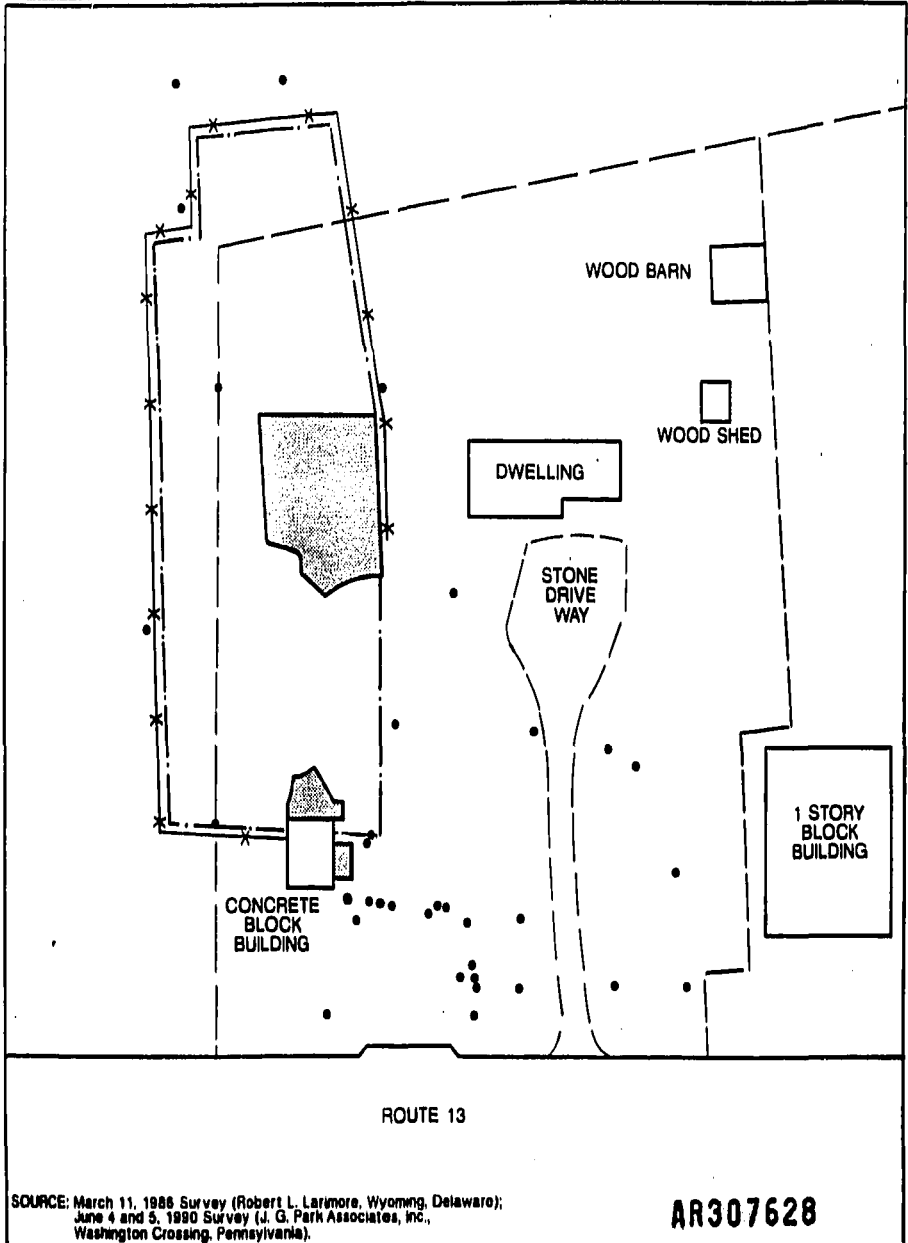
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SECTION 5.0

FIGURES

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SOURCE: March 11, 1988 Survey (Robert L. Larnore, Wyoming, Delaware);
June 4 and 5, 1990 Survey (J. G. Park Associates, Inc.,
Washington Crossing, Pennsylvania).

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0 50 Feet

NORTH

LEGEND

● Monitoring Well

— Property Line

□ Concrete

--- Biological Assessment Study Area Boundary

—+— Fence

Figure 5-1
Biological Assessment
Boundary

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PHOTOGRAPH 1
Looking toward northwest corner of site from wet 34. Area 1 is in the background. Area 2 is in the foreground.



PHOTOGRAPH 2
Looking east from wet 34. Area 2 is in the foreground. Area 3 is in the background.



PHOTOGRAPH 3
Looking south from remains of concrete pad 1. In photograph is characteristic of Area 2.



PHOTOGRAPH 4
Looking southwest from remains of concrete pad. Area 2 is in the foreground. Area 3 is in the background.

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Figure 5-2
Plant Communities

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SECTION 5.0

TABLES

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TABLE 5-1

SUMMARY OF SOIL SAMPLES AND COMPARISON TO BACKGROUND CONCENTRATIONS

CHEM-SOLV, INC. SITE REMEDIATION INVESTIGATION
CHESWOLD, DELAWARE

Parameter (Units)	Frequency of Detection			Concentrations in Soils					Southern NJ/ Maryland/ Delaware (e)	Eastern U.S. Geometric Mean (d)	
	No. of Analyses	No. of Detects	Quantitation Limit *	BCM Results		Northern Delaware (a)	Delaware (b)				
				Maximum	Arithmetic Average **		Mean	SD			
<u>Volatiles Organics (ug/kg)</u>											
Methylene Chloride	21	11 (1)	5	15 (4.0)	NA	—	—	—	—	—	
Acetone	21	16 (0)	10	400 (-)	38.2	—	—	—	—	—	
Chloroform	21	4 (4)	5	8.0 (8.0)	3.6	—	—	—	—	—	
Trichloroethene	21	2 (2)	5	6.0 (6.0)	3.1	—	—	—	—	—	
<u>Semi-Volatiles Organics (ug/kg)</u>											
Benzoic Acid	15	1	2,000	290	NA	—	—	—	—	—	
bis(2-ethylhexyl) phthalate	15	5	390	510	198.8	—	—	—	—	—	
Isophorone	15	2	390	3,100	497.1	—	—	—	—	—	
<u>Metals (mg/kg)</u>											
Aluminum	14	14	71	17,900	12,563	30,000	—	—	700 - 30,000	—	
Arsenic	14	14	1	10.7	3.7	<0.1 - 2.6	—	—	19 - 41	—	
Berium	14	14	1.7	103.1	53.7	500	—	—	10 - 300	300	
Beryllium	14	5	0.7	0.89	0.3	<1	—	—	<1	—	
Cadmium	14	11	0.61	1.7	0.6	—	0.17	0.06	—	1.8	
Calcium	14	14	8.2	1,880	655.8	130 - 2,300	—	—	130 - 5,200	—	
Chromium	14	14	4.1	15.8	10.2	50	—	—	1 - 30	36	
Cobalt	14	13	2.4	9	4.3	3 - 5	—	—	<3	7	
Copper	14	14	3.9	14	6	<1 - 10	5	2.2	<1 - 20	14	
Iron	14	14	5.1	115,000	9,914	<7,000	—	—	100 - 10,000	15,000	
Lead	14	14	1	80	22	20	10	2	<10 - 20	14	
Magnesium	14	14	4.4	1,030	591.5	0 - 1,500	—	—	50 - 3,000	—	
Manganese	14	14	4	255	134.7	150	—	—	<2 - 300	285	
Nickel	14	12 (9)	3.7	8.8	5.7	7 - 10	6.6	4.4	<5 - 10	13	
Potassium	14	14 (10)	674	831	517.8	15,000	—	—	2,200 - 11,000	—	
Selenium	14	1	0.21	0.3	0.2	0.5	—	—	<0.1 - 0.3	—	
Sodium	14	13 (8)	16.2	141	59.1	0 - 5,000	—	—	<500 - 5,000	—	
Vanadium	14	14	8.1	25.1	18.1	30 - 50	—	—	<7 - 50	46	
Zinc	14	14 (13)	4	98.6	39.6	62	25	9	<5 - 198	36	
<u>Pesticides (ug/kg)</u>											
4,4'-DDE	14	10	0.1	275	59.7	—	—	—	—	—	
4,4'-DDT	14	9	0.1	92.5	24.8	—	—	—	—	—	
4,4'-DDD	14	2	0.1	23	3.1	—	—	—	—	—	

* Quantitation limit varies between samples

** One half of the quantitation limit was used when the chemical concentration was not detected. Duplicate samples were averaged.

SD Standard Deviation

— Data not available

NA Not Applicable - average concentration exceeded the maximum concentration

.. Valid, value not questionable due to related blanks

- a Shacklette & Boemgen, 1984. Element Concentrations in Soils and other Surficial Materials of the Conterminous United States. **AB207631**
- b Logan, T.G. and Ryan, J.A., 1987. Land Application of Sludge. Lewis Publishers, Chelsea, MI.
- c Pennsylvania State University, 1988. Criteria and Recommendations for Land Applications of Sludges in the Northeast. Bulletin 861, March 1988.
- d USEPA, 1988. Water Quality Assessment: A Screening Procedure for Toxic and Conventional Pollutants in Surface and Ground Water - Part 1. EPA/800/8-88/002a. September 1988 Revised.
- e USEPA, 1984. Health Assessment Document for Inorganic Arsenic. EPA/800/8-83/021F. March 1984.

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TABLE 5-2

CHEMICALS DETECTED IN GROUNDWATER - NEAR WELLS*

CHEM-SOLV, INC. SITE REMEDIAL INVESTIGATION
CHESWOLD, DELAWARE

Chemical	Frequency of Detection **	Range of Sample Quan- titation Limits (ug/l)	Range of Detected Concentrations (ug/l)	Background Levels (ug/l)
Acetone	2 / 16	10 - 50	110	< 10
Benzene	5 / 16	5 - 25	12 - 200	< 5
1,1-Dichloroethane	1 / 16	5 - 25	2	< 5
1,2-Dichloroethane	1 / 16	5 - 25	5	< 5
cis-1,2-Dichloroethene	1 / 16	5 - 25	1.4 - 1.5	< 5
Tetrachloroethene	5 / 16	5 - 25	1.3 - 6	< 5
Toluene	1 / 16	5 - 25	3	< 5
1,1,1- Trichloroethane	6 / 16	5 - 25	3 - 23	< 5
Trichloroethene	7 / 16	5 - 25	5 - 540	< 5
Xylene	1 / 16	5 - 25	0.4	< 5
Manganese ***	13 / 13	2.8	15.9 - 24,400	11.3 - 117
Zinc ***	11 / 11	5	10.5 - 3,340	29.6 - 49.6

* Near wells include: 2bA, 33A, 39A, 5B, and 9B

** Number of samples in which the chemical was positively detected divided by the number of samples available, including duplicate and split samples

*** Values for unfiltered sample results

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TABLE 5-3

CHEMICALS DETECTED IN GROUNDWATER - FAR WELLS*

CHEM-SOLV, INC. SITE REMEDIAL INVESTIGATION
CHESWOLD, DELAWARE

Chemical	Frequency of Detection**	Range of Sample Quantitation Limits (ug/l)	Range of Detected Concentrations (ug/l)	Background Levels (ug/l)
Acetone	1 / 23	10 - 50	110	< 10
Benzene	5 / 23	5 - 25	12 - 200	< 5
Chloroform	1 / 23	5 - 25	2	< 5
1,1-Dichloroethane	1 / 23	5 - 25	2	< 5
1,2-Dichloroethane	2 / 23	5 - 25	5	< 5
cis-1,2-Dichloroethane	2 / 23	5 - 25	1.4 - 1.5	< 5
Tetrachloroethene	5 / 23	5 - 25	1.3 - 6	< 5
Toluene	1 / 23	5 - 25	3	< 5
1,1,1-Trichloroethane	7 / 23	5 - 25	3 - 54	< 5
Trichloroethene	7 / 23	5 - 25	5 - 540	< 5
Xylene	1 / 23	5 - 25	0.4	< 5
Manganese ***	21 / 21	2.8	15.9 - 23,400	11.3 - 117
Zinc ***	19 / 19	5	7 - 3,810	29.6 - 49.6

* Far wells include: near wells (28A, 33A, 39A, 5B, and 9B), 41A, MWS-5-18, MWS-6-25, the American Roofing, and Gearhart wells. MWS-7-25 included for manganese and zinc only

** Number of samples in which the chemical was positively detected divided by the number of samples available, including duplicate and split samples

*** Values for unfiltered samples

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TABLE 5-4

ASSUMPTIONS USED IN CALCULATING EXPOSURE

CHEM-SOLV, INC. SITE REMEDIAL INVESTIGATION
CHESWOLD, DELAWARE

	Children	Adults	Reference
<u>Ingestion of Groundwater</u>			
Ingestion Rate (liters/day)	1.3	2	EPA (1989a and 1989b)
Exposure Frequency (events/year)	365	365	Site Specific
Exposure Duration (years)	5	30	EPA (1989a and 1989b)
Body Weight (kg)	17	70	EPA (1989a and 1989b)
<u>Dermal Absorption from Groundwater Use</u>			
Skin surface area (sq. cm)	7,128	19,400	EPA (1989a and 1989b)
Exposure time (hours/event)	0.25	0.25	EPA, 1989c
Exposure frequency (events/year)	365	365	Site Specific
Exposure duration (years)	5	30	Site Specific
Body weight (kg)	17	70	EPA (1989a and 1989b)
<u>Inhalation from Groundwater Use</u>			
Drinking Water Equivalent Factor*		0.95	EPA, 1988

* See Section 5.3.2.2 and Appendix Q

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TABLE 5-5

CONCENTRATIONS USED IN RISK ASSESSMENT CALCULATIONS

CHEM-SOLV, INC. SITE REMEDIAL INVESTIGATION
CHESWOLD, DELAWARE

Chemical	Concentration			
	Far Well Group (ug/l)		Near Well Group (ug/l)	
	Average	RME	Average	RME
Acetone	5.5	10.3	7.7	19.1
Benzene	9.4	23.5	17.4	50.1
Chloroform	1.3	1.7	-	-
1,1-Dichloroethane	1.2	1.6	0.9	1.3
1,2-Dichloroethane	1.7	2.5	1.4	2.3
cis-1,2-Dichloroethene	1.6	1.9	1.4	1.8
Tetrachloroethene	1.7	2.1	1.7	2.3
Toluene	1.4	1.8	1.2	1.6
1,1,1-Trichloroethane	5.5	10.8	4.3	10.9
Trichloroethene	35.2	96.1	68.9	210.4
Xylene	1.5	1.9	1.4	1.7
Manganese*	2,608.9	6,318.1	4,900.4	14,562.4
Zinc*	381.3	957.9	751.4	2,248.7

* Values for unfiltered sample results

- Compound not detected in the well group

RME Reasonable maximum exposure is defined as the upper bound 95 percent confidence interval of the arithmetic average.

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TABLE 5-6
TOXICITY VALUES: POTENTIAL CARCINOGENIC EFFECTS
CHEM-SOLV, INC. SITE REMEDIAL INVESTIGATION
CHESWOLD, DELAWARE

Chemical	Slope Factor (mg/kg/day) ⁻¹	Weight-of- Evidence Classification	Tumor Site	Source of Slope Factor	Model
Benzene	Oral Inhalation	A 0.029	[1]	IRIS	One hit (pooled data)
Chloroform	Oral Inhalation	A 0.029 0.0061	[1] Kidney	IRIS	One hit (pooled data)
1,2-Dichloroethane	Oral Inhalation	B2 0.081	Kidney, Liver	IRIS	Linearized multistage (extra risk)
Tetrachloroethene	Oral Inhalation	B2 0.091 0.091	Circulatory System	IRIS	Linearized multistage (extra risk)
Trichloroethene	Oral Inhalation	B2 0.051 0.0018 0.011 0.017	Liver Leukemia, Liver Liver Lung	IRIS HEAST HEAST HEAST	Linearized multistage (extra risk) NA NA NA NA

IRIS Not available
IRIS Integrated Risk Information System
HEAST Health Effects Assessment Summary Tables
HEAST Acute myelogenous leukemia and aplastic anemia
66
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TABLE 5-7

TOXICITY VALUES: POTENTIAL NONCARCINOGENIC EFFECTS

CHEM-SOLV, INC. SITE REMEDIAL INVESTIGATION
CHESWOLD, DELAWARE

Chemical		Chronic RfD * (mg/kg/day)	Confidence Level	Critical Effect	RfD Source	Uncertainty and Modifying Factors	
						UF	MF
Acetone	Oral	0.1	Low	Kidney, Liver	IRIS	1000	1
Chloroform	Oral	0.01	Medium	Liver	IRIS	1000	1
Tetrachloroethene	Oral	0.01	Medium	Liver	IRIS	1000	1
Toluene	Oral	0.2	Medium	Blood	IRIS	100	1
	Inhalation	0.6 a	Medium	CNS, Liver, Kidney	IRIS	NA	NA
1,1,1-Trichloroethane	Oral	0.09	Medium	Liver	IRIS	1000	1
Xylene	Oral	2	Medium	Mortality	IRIS	100	1
	Inhalation	0.2	Medium	CNS, Mortality	HEAST	NA	NA
Manganese	Oral	0.1	Medium	CNS	IRIS	1	NA
Zinc	Oral	0.2	NA	Anemia	HEAST	NA	NA

NA Not available

IRIS Integrated Risk Information System

HEAST Health Effects Assessment Summary Table

* Inhalation reference dose (RfD) values have not been determined; oral RfD values were used in the exposure calculations, except for 1,1,1-trichloroethane. HEAST lists an inhalation RfD of 0.3 mg/kg/day for 1,1,1-trichloroethane. Critical effect is the central nervous system with an uncertainty factor of 100.

a EPA comments for the draft RI report dated September 17, 1990, p.23, recommended an inhalation RfD of 1.5 mg/kg/day. A more conservative value of 0.6 mg/kg/day was obtained from 4th Quarter 1990 HEAST.

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TABLE 5-8

EPA CATEGORIES FOR POTENTIAL CARCINOGENS

CHEM-SOLV, INC. SITE REMEDIAL INVESTIGATION
CHESWOLD, DELAWARE

EPA Category	Group Description	Evidence
Group A	Human Carcinogen	Sufficient evidence from epidemiologic studies to support a causal association between exposure and cancer in humans
Group B1	Probable Human Carcinogen	Limited evidence in humans from epidemiologic studies
Group B2	Possible Human Carcinogen	Sufficient evidence in animals, inadequate evidence in humans
Group C	Possible Human Carcinogen	Limited evidence in animals and/or carcinogenic properties in short-term studies
Group D	Not Classified	Inadequate evidence in animals
Group E	No Evidence	No evidence in at least two adequate animal tests or in both epidemiologic and animal studies

Source: EPA, 1988

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TABLE 5-9

CANCER RISK ESTIMATES - NEAR WELLS

CHEM-SOLV, INC. SITE REMEDIAL INVESTIGATION
CHESWOLD, DELAWARE

Chemical	Slope Factor	CDI (mg/kg/day)		Weight of Evidence	Chemical Specific Risk		Total Exposure Pathway	
		Average	RME		Average	RME	Average	RME
Exposure Pathway: Ingestion of Contaminated Groundwater								
Benzene	0.029	2E-04	6E-04	A	6E-06	2E-05		
1,2-Dichloroethane	0.091	2E-05	3E-05	B2	2E-06	3E-06		
Tetrachloroethene	0.051	2E-05	3E-05	B2	1E-06	1E-06		
Trichloroethene	0.011	6E-04	3E-03	B2	9E-06	3E-05		
							2E-05	5E-05
Exposure Pathway: Inhalation of Contaminants in Groundwater During Use								
Benzene	0.029	2E-04	6E-04	A	6E-06	2E-05		
1,2-Dichloroethane	0.091	2E-05	3E-05	B2	1E-06	2E-06		
Tetrachloroethene	0.0018	2E-05	3E-05	B2	4E-06	5E-06		
Trichloroethene	0.017	6E-04	2E-03	B2	1E-06	4E-05		
							2E-05	6E-05
Exposure Pathway: Dermal Absorption of Contaminants in Groundwater During Use								
Benzene	0.029	6E-05	2E-04	A	2E-06	7E-06		
1,2-Dichloroethane	0.091	4E-06	7E-06	B2	4E-07	6E-07		
Tetrachloroethene	0.051	1E-05	1E-05	B2	5E-07	7E-07		
Trichloroethene	0.011	1E-05	4E-05	B2	1E-07	4E-07		
							3E-06	9E-06
TOTAL EXPOSURE							4E-05	1E-04

RME Reasonable maximum exposure is defined as the upper bound 95 percent confidence interval of the arithmetic average

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TABLE 5-10

CANCER RISK ESTIMATES - FAR WELLS

CHEM-SOLV, INC. SITE REMEDIAL INVESTIGATION
CHESWOLD, DELAWARE

Chemical	CDI (mg/kg/day)		Slope Factor	Weight of Evidence	Chemical Specific Risk		Total Exposure Pathway	
	Average	RME			Average	RME	Average	RME
Exposure Pathway: Ingestion of Contaminated Groundwater								
Benzene	1E-04	3E-04	0.029	A	3E-06	8E-06		
Chloroform	2E-05	2E-05	0.0081	B2	1E-07	1E-07		
1,2-Dichloroethane	2E-05	3E-05	0.001	B2	2E-06	3E-06		
Tetrachloroethene	2E-05	3E-05	0.051	B2	1E-06	1E-06		
Trichloroethene	4E-04	1E-03	0.011	B2	5E-06	1E-05	1E-05	3E-05
Exposure Pathway: Inhalation of Contaminants in Groundwater During Use								
Benzene	1E-04	3E-04	0.029	A	3E-06	8E-06		
Chloroform	2E-05	2E-05	0.001	B2	1E-06	2E-06		
1,2-Dichloroethane	2E-05	3E-05	0.001	B2	2E-06	3E-06		
Tetrachloroethene	2E-05	2E-05	0.0018	B2	3E-06	4E-06		
Trichloroethene	4E-04	1E-03	0.017	B2	7E-06	2E-05	1E-05	3E-05
Exposure Pathway: Dermal Absorption of Contaminants in Groundwater During Use								
Benzene	4E-05	1E-04	0.029	A	1E-06	3E-06		
Chloroform	4E-06	5E-06	0.0081	B2	2E-08	3E-08		
1,2-Dichloroethane	5E-06	5E-06	0.001	B2	5E-07	7E-07		
Tetrachloroethene	1E-06	1E-06	0.051	B2	5E-07	6E-07		
Trichloroethene	6E-06	2E-05	0.011	B2	7E-06	2E-07	2E-06	5E-06
TOTAL EXPOSURE							3E-05	6E-05

RME Reasonable maximum exposure is defined as the upper bound 95 percent confidence interval of the arithmetic average

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TABLE 5-11

CHRONIC HAZARD INDEX ESTIMATES - NEAR WELLS

CHEM-SOLV, INC. SITE REMEDIAL INVESTIGATION
CHESWOLD, DELAWARE

Chemical	CDI (mg/kg-day)		RID (mg/kg/day)	Hazard Index		Pathway Hazard Index	
	Average	RME		Average	RME	Average	RME
Exposure Pathway: Ingestion of Contaminated Groundwater							
ADULTS							
Acetone	2E-04	5E-04	0.1	2E-03	5E-03		
Tetrachloroethene	5E-05	7E-05	0.01	5E-03	7E-03		
Toluene	3E-05	5E-05	0.2	2E-04	2E-04		
1,1,1-Trichloroethane	1E-04	3E-04	0.09	1E-03	3E-03		
Xylene	4E-05	5E-05	2	2E-05	2E-05		
Manganese	1E-01	4E-01	0.1	1E+00	4E+00		
Zinc	2E-02	6E-02	0.2	1E-01	3E-01		
						2E+00	4E+00
CHILDREN							
Acetone	6E-04	1E-03	0.1	6E-03	1E-02		
Tetrachloroethene	1E-04	2E-04	0.01	1E-02	2E-02		
Toluene	9E-05	1E-04	0.2	4E-04	6E-04		
1,1,1-Trichloroethane	3E-04	6E-04	0.09	4E-03	9E-03		
Xylene	1E-04	1E-04	2	5E-05	6E-05		
Manganese	4E-01	1E+00	0.1	4E+00	1E+01		
Zinc	6E-02	2E-01	0.2	3E-01	9E-01		
						4E+00	1E+01
Exposure Pathway: Inhalation of Contaminants in Groundwater During Use							
ADULTS							
Acetone	2E-04	5E-04	0.1	*	2E-03	5E-03	
Tetrachloroethene	5E-05	6E-05	0.01	*	5E-03	6E-03	
Toluene	3E-05	4E-05	0.6	*	5E-05	7E-05	
1,1,1-Trichloroethane	1E-04	3E-04	0.09	*	1E-03	3E-03	
Xylene	4E-05	5E-05	0.2	*	2E-04	2E-04	
						6E-03	2E-02
CHILDREN							
Acetone	6E-04	1E-03	0.1	*	6E-03	1E-02	
Tetrachloroethene	1E-04	2E-04	0.01	*	1E-02	2E-02	
Toluene	9E-05	1E-04	0.6	*	1E-04	2E-04	
1,1,1-Trichloroethane	3E-04	6E-04	0.09	*	3E-03	9E-03	
Xylene	1E-04	1E-04	0.2	*	5E-04	6E-04	
						2E-02	4E-02

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Table S-11(Continued)

Chemical	CDI (mg/kg-day)		RfD (mg/kg-day)	Hazard Index		Pathway Hazard Index	
	Average	RME		Average	RME	Average	RME
Exposure Pathway: Dermal Absorption of Contaminants in Groundwater During Use							
ADULTS							
Acetone	3E-06	7E-06	0.1	3E-05	7E-05		
Tetrachloroethene	2E-06	3E-06	0.01	2E-03	3E-03		
Toluene	4E-06	6E-06	0.2	2E-06	3E-06		
1,1,1-Trichloroethane	3E-06	6E-06	0.09	3E-04	6E-04		
Xylene	6E-06	9E-06	2	4E-06	5E-06		
						3E-03	4E-03
CHILDREN							
Acetone	4E-06	1E-05	0.1	4E-05	1E-04		
Tetrachloroethene	4E-06	5E-06	0.01	4E-03	5E-03		
Toluene	6E-06	6E-06	0.2	3E-05	4E-05		
1,1,1-Trichloroethane	4E-05	1E-04	0.09	5E-04	1E-03		
Xylene	1E-05	1E-05	2	6E-06	7E-06		
						4E-03	6E-03
TOTAL EXPOSURE - ADULTS						2E+00	5E+00
TOTAL EXPOSURE - CHILDREN						4E+00	1E+01

* Inhalation reference dose (RfD) values have not been determined; oral RfD values were used in the exposure calculations, except for 1,1,1-trichloroethane. HEAST lists an inhalation RfD of 0.3 mg/kg/day for 1,1,1-trichloroethane. Critical effect is the central nervous system and uncertainty factor of 100.

RME Reasonable maximum exposure is defined as the upper bound 95 percent confidence interval of the arithmetic average

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TABLE 5-12

CHRONIC HAZARD INDEX ESTIMATES - FAR WELLS

CHEM-SOLV, INC. SITE REMEDIAL INVESTIGATION
CHESWOLD, DELAWARE

Chemical	CDI (mg/kg/day)		RID (mg/kg/day)	Hazard Index		Pathway Hazard Index	
	Average	RME		Average	RME	Average	RME
Exposure Pathway: Ingestion of Contaminated Groundwater							
ADULTS							
Acetone	6E-04	1E-03	0.1	6E-03	1E-02		
Chloroform	2E-04	2E-04	0.01	2E-02	2E-02		
Tetrachloroethene	2E-04	2E-04	0.01	2E-02	2E-02		
1,1,1-Trichloroethane	6E-04	1E-03	0.09	7E-03	1E-02		
Toluene	2E-04	2E-04	0.2	6E-04	1E-03		
Xylene	2E-04	2E-04	2	9E-05	1E-04		
Manganese	3E-01	7E-01	0.1	3E+00	7E+00		
Zinc	4E-02	1E-01	0.2	2E-01	6E-01		
						3E+00	8E+00

<u>CHILDREN</u>							
Acetone	4E-04	8E-04	0.1	4E-03	6E-03		
Chloroform	1E-04	1E-04	0.01	1E-02	1E-02		
1,1,1-Trichloroethane	1E-04	2E-04	0.01	1E-02	2E-02		
Tetrachloroethene	1E-04	1E-04	0.2	5E-04	7E-04		
Toluene	4E-04	8E-04	0.09	5E-03	9E-03		
Xylene	1E-04	1E-04	2	6E-05	7E-05		
Manganese	2E-01	5E-01	0.1	2E+00	5E+00		
Zinc	3E-02	7E-02	0.2	1E-01	4E-01		
						2E+00	5E+00

Exposure Pathway: Inhalation of Contaminants in Groundwater During Use							
<u>ADULTS</u>							
Acetone	1E-04	3E-04	0.1	*	1E-03	3E-03	
Chloroform	4E-05	5E-05	0.01	*	4E-03	5E-03	
Tetrachloroethene	4E-05	6E-05	0.01	*	4E-03	6E-03	
Toluene	4E-05	5E-05	0.6	*	6E-05	8E-05	
1,1,1-Trichloroethane	1E-04	3E-04	0.09	*	2E-03	3E-03	
Xylene	4E-05	5E-05	0.2	*	2E-04	3E-04	
						1E-02	2E-02

<u>CHILDREN</u>							
Acetone	4E-04	8E-04	0.1	*	4E-03	6E-03	
Chloroform	9E-05	1E-04	0.01	*	9E-03	1E-02	
Tetrachloroethene	1E-04	1E-04	0.01	*	1E-02	1E-02	
Toluene	1E-04	1E-04	0.6	*	2E-04	2E-04	
1,1,1-Trichloroethane	4E-04	8E-04	0.09	*	4E-03	9E-03	
Xylene	1E-04	1E-04	0.2	*	6E-04	7E-04	

3E-02 4E-02
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Table 5-12 (Continued)

Chemical	CDI (mg/kg/day)		Oral RID (mg/kg/day)	Hazard Index		Pathway Hazard Index	
	Average	RME		Average	RME	Average	RME
Exposure Pathway: Dermal Absorption of Contaminants in Groundwater During Use							
ADULTS							
Acetone	2E-08	4E-08	0.1	2E-08	4E-08		
Chloroform	9E-08	1E-08	0.01	9E-04	1E-03		
Tetrachloroethene	2E-08	3E-05	0.01	2E-03	3E-03		
1,1,1-Trichloroethane	8E-08	6E-08	0.2	2E-08	3E-08		
Toluene	4E-08	7E-05	0.09	4E-04	8E-04		
Xylene	8E-08	1E-05	2	4E-08	5E-08	4E-03	5E-03
CHILDREN							
Acetone	3E-08	5E-08	0.1	3E-08	5E-08		
Chloroform	6E-08	1E-05	0.01	6E-04	1E-03		
Tetrachloroethene	3E-08	4E-05	0.01	3E-03	4E-03		
1,1,1-Trichloroethane	7E-08	9E-08	0.2	4E-08	5E-08		
Toluene	6E-08	1E-04	0.09	6E-04	1E-03		
Xylene	1E-08	2E-05	2	6E-08	8E-08	6E-03	7E-03
TOTAL EXPOSURE - ADULTS						3E+00	8E+00
TOTAL EXPOSURE - CHILDREN						2E+00	6E+00

* Inhalation reference dose (RID) values have not been determined; oral RID values were used in the exposure calculations, except for 1,1,1-trichloroethane. HEAST lists an inhalation RID of 0.3 mg/kg/day for 1,1,1-trichloroethane. Critical effect is the central nervous system and uncertainty factor of 100.

RME Reasonable maximum exposure is defined as the upper bound 95 percent confidence interval of the arithmetic average

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TABLE 5-13

SUMMARY OF RISK

CHEM-SOLV, INC. SITE REMEDIAL INVESTIGATION
CHESWOLD, DELAWARE

Pathway	CANCER RISK		HAZARD INDEX			
	Average	RME	Average		RME	
			Adults	Children	Adults	Children
<hr/>						
<u>Far Wells</u>						
Ingestion	1E-05	3E-05	3E+00	2E+00	8E+00	5E+00
Inhalation	1E-05	3E-05	1E-02	3E-02	2E-02	4E-02
Dermal	2E-06	5E-06	4E-03	5E-03	5E-03	7E-03
TOTAL	3E-05	6E-05	3E+00	2E+00	8E+00	5E+00
<u>Near Wells</u>						
Ingestion	2E-05	5E-05	2E+00	4E+00	4E+00	1E+01
Inhalation	2E-05	6E-05	8E-03	2E-02	2E-02	4E-02
Dermal	3E-06	9E-06	3E-03	4E-03	4E-03	6E-03
TOTAL	4E-05	1E-04	2E+00	4E+00	5E+00	1E+01

RME Reasonable maximum exposure is defined as the upper bound 95 percent confidence interval of the arithmetic average.

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TABLE 5-14

COMPARISON OF WATER QUALITY GUIDELINES TO PREDICTED
ENVIRONMENTAL CONCENTRATIONSCHEM-SOLV, INC. SITE REMEDIAL INVESTIGATION
CHESWOLD, DELAWARE

Chemical	Water Quality Guidelines (ug/l)*		Predicted Concentrations at the Point of Release (ug/l)**	
	Acute	Chronic	Average	RME
Acetone	(a)	(a)	0.4	0.7
Benzene	5,300	53 e	0.6	1.6
Chloroform	28,900	1,240	0.1	0.1
1,1-Dichloroethane	NA	NA	0.1	0.1
1,2-Dichloroethane	110,000	20,000	0.1	0.2
1,2-Dichloroethene	11,400	114 e	0.1	0.1
Tetrachloroethene	5,280	840	0.1	0.1
Toluene	17,500	175 e	0.1	0.1
1,1,1-Trichloroethane	9,320	93 e	0.4	0.7
Trichloroethene	45,000	21,900	2.4	6.5
Manganese	NA	NA	177.2	429.2
Zinc	180 c	110 b	25.9 b	65.1
			4.3 d	6.4 d

* EPA, 1986. Gold Book: Quality Criteria for Water. EPA 440/S-86-1

** Average and RME groundwater concentrations (far wells) diluted to estimate
concentrations at the point of release (Alston Branch of the Leipsic River)Dilution Factor = $\frac{\text{Site water shed area}}{\text{Area of far well plume}} = \frac{5.3E+08}{3.6E+05} = 15$

a Recommended solvent carrier for aquatic bioassays: non-toxic

b Value recommended by EPA in Comments to draft RI (September 17, 1990, p. 22).

c Based on hardness in background well (22A) of 48 mg/l as CaCO₃

d Well 33A not included to calculate average groundwater concentrations

e Value for acute guideline multiplied by 0.01 (EPA 1984)

RME Reasonable maximum exposure

NA Not available

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TABLE 5-15

PRESENCE - ABSENCE MATRIX OF PREDOMINANT PLANT TAXA WITHIN
THE THREE PLANT COMMUNITIESCHEM-SOLV, INC. SITE REMEDIAL INVESTIGATION
CHESWOLD, DELAWARE

Common Name	Scientific Name	Community		
		I	II	III
White clover	Trifolium repens	+	+	+
Low hop clover	Trifolium procumbens	+	+	+
Rabbit-foot clover	Trifolium arvense	+	-	-
Cow vetch	Vicia cracca	+	+	-
Yellow sweet clover	Melilotus officinalis	+	+	-
Plantain	Plantago sp.	+	+	-
Fleabane	Erigeron sp.	+	+	+
Aster	Aster sp.	+	+	+
Ragweed	Ambrosia sp.	-	+	+
Hungarian brome	Bromus inermis	+	-	-
Little bluestem	Andropogon sp.	+	+	-
Japanese brome	Bromus japonicus	+	+	+
Ironweed	Veronica sp.	+	+	+
Dock	Rumex sp.	+	+	+
Wild onion	Allium cernuum	+	+	+
Mustard	Brassica sp.	-	+	+
Rush	Juncus sp.	-	-	+
Wild berry	Rubus sp.	-	-	+
Japanese honeysuckle	Lonicera japonica	-	-	+

+ Denotes presence of taxa

- Denotes absence of taxa

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SECTION 6.0

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6.0 CONCLUSIONS

An evaluation of data obtained for the Chem-Solv, Inc. site supports the following conclusions:

- After an explosion and fire on September 7, 1984, at the Chem-Solv site, DNREC initiated soil and groundwater investigations to evaluate possible contamination. Volatile organic compounds, including TCE and related compounds, were identified in onsite soil and groundwater.
- Groundwater from the shallow aquifer beneath the site from the shallow aquifer has been affected by organic compounds from site activities and nonsite activities. Compounds resulting from site activities include TCE and related compounds. Other compounds, which include benzene and toluene, cannot be directly related to the site. Data presented in the RI support the conclusion that these compounds are most likely to come from an offsite source or sources. The previous operation of the groundwater treatment system has resulted in the co-mingling of these compounds. A groundwater plume extends in the shallow groundwater from the area below the former distillation building to the eastern edge of Route 13. Impacts to the deeper zones of the aquifer have been limited by the presence of a silt layer approximately 20 feet below the ground surface in the vicinity of the site. However, some VOC contamination of the intermediate zone has occurred, as indicated by low levels of VOCs in the intermediate-zone monitoring wells and nearby domestic wells.
- The elevated levels of manganese and zinc may be the result of local anaerobic groundwater conditions. However, the cause of these localized conditions is unknown.
- A second distinct plume associated with leaking underground storage tanks has been identified in the shallow aquifer zone just north of the intersection of Routes 13 and 42. Groundwater quality data, hydrogeologic information, and soil analytical data obtained from the Underground Storage Tank Branch of DNREC indicate that sources other than the Chem-Solv site are involved.
- Carcinogenic risks associated with the site, including ingestion of groundwater, inhalation during use, and dermal contact with groundwater, all fall within the target range of 1×10^{-4} to 1×10^{-6} .

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- Noncarcinogenic risks for the site associated with the ingestion of groundwater are above the accepted HI value of 1. However, manganese contributes 60 to 100 percent of the total risk. Based on a review of the data, manganese may not be site related. If manganese is excluded from the groundwater ingestion calculation, hazard index values for noncarcinogenic risk are below 1 for both adults and children.

SECTION 7.0

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